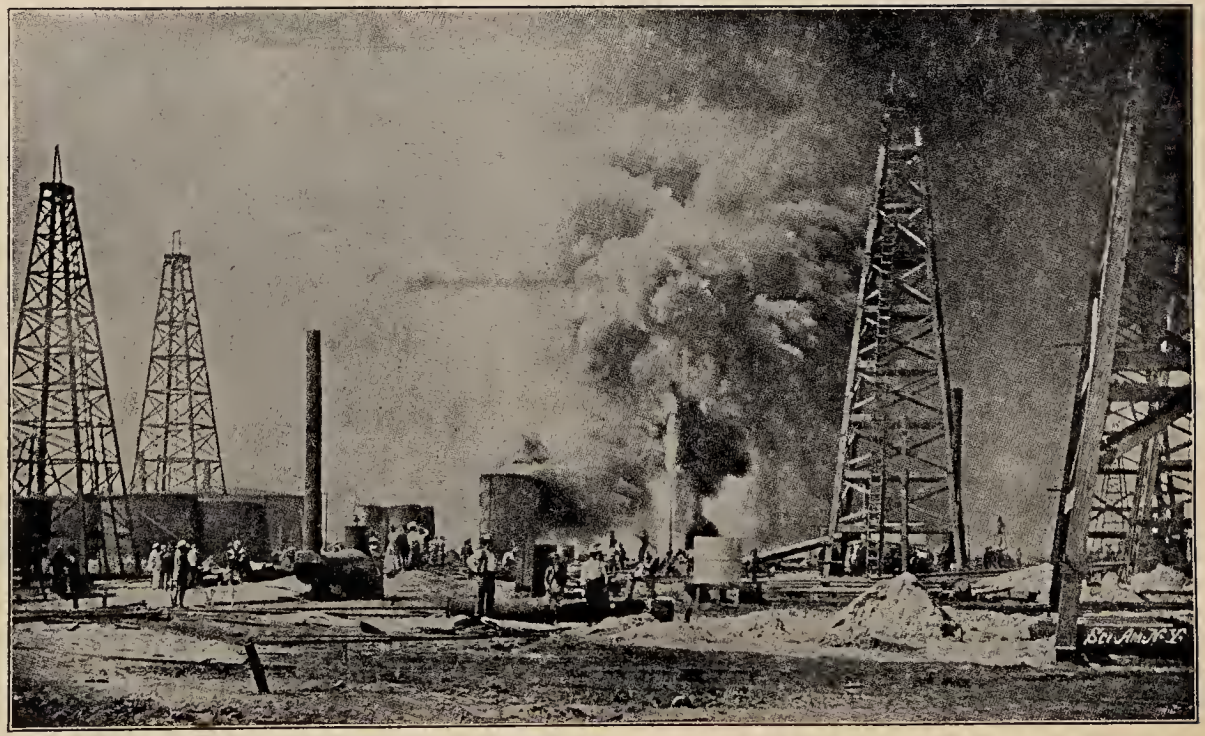
THE
STORY OF OIL



A Familiar Scene in the Oil Fields: a Well and Tank on Fire.

THE STORY OF OIL

BY

WALTER SHELDON TOWER, PH.D.

ASSISTANT PROFESSOR OF GEOGRAPHY
UNIVERSITY OF PENNSYLVANIA

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TO

L. W. T.

WHOSE ACTIVE INTEREST AND FRIENDLY
CRITICISMS HAVE AIDED MATERIALLY
IN THE PREPARATION OF
THIS VOLUME

PREFACE

RECENT years have been marked by prolific crops of "studies in oil," but dealing mainly with some special phase of the oil business, frequently with disputed points of an ethical or a legal nature. Few, indeed, are the volumes giving in convenient form an account from which the reader may survey the entire industry and judge its importance for himself. It is hoped, therefore, that this "story of oil," told in nontechnical terms, may serve a double purpose: first, to portray, without prejudice or passion, the enormous developments in the petroleum industry during the last fifty years; and second, to point out the important part which petroleum and its products play in everyday life. Few industries, even in this age of huge enterprises, can rival the petroleum industry in its rapid strides of progress; none can surpass it in the magnitude and range of its operations; no other has been so completely American in its development. For this reason most of the volume

deals with the evolution of the industry in the United States.

Much more might have been made of the spectacular side of the industry, but that is, on the whole, the aspect which has been most exploited, and its incorporation here would have been at the expense of other less familiar aspects. Little has been said here about the moral and legal aspects of Standard Oil activities. If, on the contrary, much more than the usual amount of credit is given to that company, it is merely a result of trying to do justice where but one side of the question is ordinarily considered.

In the preparation of the volume valuable material has been drawn from many sources, especially from the publications of the United States Geological Survey and other Federal Bureaus, as well as from various periodicals, particularly from the *Petroleum Age*, the *Mineral Industry*, and the *Scientific American;* indebtedness to them is hereby gratefully acknowledged.

W. S. T.

PHILADELPHIA.

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CHAPTER I

THE NATURE AND OCCURRENCE OF PETROLEUM

Fifty years ago more than half the world lived in darkness for want of a suitable light. Coal gas for illuminating purposes had come into more or less general use in the cities and some of the larger towns, and burning oils for lamps had been successfully manufactured from coal and shale rocks in several European countries, as well as in the United States. But the great mass of the country folk of the world were still restricted to the use of dim candles, or vile-smelling, spluttering lamps which burned animal or vegetable oils. Hordes of people in India, China, and Russia were trying pitifully to make light with tallow fats in an open cup, and rude wicks fashioned from plant fiber. Little wonder it is that in the days of our grandfathers "early to bed" was the rule, for there was no pleasure to be found in spending an evening with only the fitful flickering of a candle to light the dreary hours.

Now all is changed. Night is turned into day by the powerful gas and electric lamps of the

great city, where the stream of life never ceases throughout the twenty-four hours. Great, indeed, is the service which these lights perform for the complex life of the modern metropolis. But greater still is the service which has been done by the humble kerosene lamp in the quiet homes of the plain people, who bear the brunt of the world's work. It has carried the light of civilization into every corner of the earth. It has literally made life longer for the millions, by turning hours of darkness into hours of profitable pleasure and enjoyment. Common as it is, the ordinary kerosene lamp is one of the greatest inventions of the world in its service and benefits to mankind. Yet kerosene is only one of a hundred necessities of everyday life which come from the world-wide deposits of petroleum.

If a hundred people were asked to name the most valuable of all the riches taken from the earth, probably half of them would promptly name one of the precious metals or gems, such as gold or diamonds, simply because a given small amount costs many dollars. The more practical minds of the other half would likely place iron first, and rightly so, perhaps, because it occupies such a vital position in relation to modern industry. Few, indeed, would be the answers giving petroleum an important place; yet, iron alone excepted, no other mineral product can rival petroleum in real value to all the peoples of the earth, without regard to class or condition. Using some of its products

constantly in every-day affairs, year in and year out, hardly one person in a hundred knows whence or how the product comes, or what petroleum is. Kerosene, gasoline, benzine, naphtha, machine oil, paraffin wax—of course, everyone knows what they are. Absurd to ask such a question! Their relation to petroleum? That is not so familiar.

This general lack of familiarity with crude petroleum may be the real reason why it is known by so many different names. Mineral oil, rock oil, stone oil, coal oil, and naphtha are some of the more common terms used for this one and the same substance. The first three of these names can be readily accounted for from the fact that petroleum is a natural oily product occurring in the crust of the earth; in fact, the word petroleum itself is derived from the Greek words meaning rock oil.

But the name coal oil, very commonly used in some places, is entirely wrong, since petroleum has no connection with coal, either in origin or any other way. The use of this term, however, arose through a perfectly natural combination of circumstances. Long before petroleum was generally known, oil was observed trickling down from seams of coal in the Shropshire mines, England. The miners, of course, supposed that the oil was derived from the coal, instead of coming from the rocks above, as was really the case, and so called it coal oil. Later, when the manufacture of oils from coal by distillation was well established, a

striking resemblance was noticed between petroleum and the oils produced artificially. This similarity still further advanced the belief that petroleum and coal were of the same origin, and that the former was really a coal oil. Finally, when the first large deposits of petroleum in this country were found in Pennsylvania, Ohio, and West Virginia, the region was already commonly associated with the idea of important coal deposits. It was soon demonstrated, both here and in other countries, that the rocks including the coal beds were entirely distinct from the rocks in which the oil was found, and that petroleum was not in any sense a "coal oil." By that time, however, the name was so firmly rooted in popular usage that no amount of argument has been able to displace it.

Petroleum belongs to the so-called bitumen family, which is made up of compounds of carbon and hydrogen, occurring either as gases, fluids, or solids, and all the result of much the same process of formation. Natural gas is the only important gaseous member of this group. Petroleum is, of course, the most important of the fluid bitumens, but the viscous earth tar, mineral tar, or maltha, as it is variously called, is also a valuable product for certain uses. A clear, waterlike, liquid form, passing under such names as rock oil and naphtha, is found occasionally in small quantities, the ordinary petroleum being always more or less colored. Among the solid bitumens, asphalt is at once the

most familiar and most valuable, while the mineral pitch and mineral wax, or ozocerite, are of fairly frequent occurrence.

The fluid petroleum may be regarded as the pivot in the group, since, under varying conditions, it will give practically every one of the different forms named. Natural gas in varying amounts is always found with petroleum, and is undoubtedly a product of its formation in underground processes. The relation of petroleum to the semisolid and solid varieties, on the other hand, depends largely on the presence of air. When petroleum is exposed to the atmosphere, evaporation and combination with oxygen gradually produce a concentration of the solid substances, with some chemical changes, resulting in the formation of tar, pitch, wax, or asphalt, as the case may be. Thus, many surface deposits of these solid bitumens which occur in different parts of the world are regarded as the result of slow exudation of petroleum from near-by subterranean accumulations.

Petroleum, the most abundant and also most valuable of the bitumens, varies greatly in character, not only from one country to another, but also in deposits relatively close together. It is always an oily liquid, sometimes thin and at others thick and viscous. The color ranges from water white, in a few rare deposits, through straw color, amber, and yellow, to a dirty brown or almost black, the darker colors being the more common.

The odor is occasionally not especially unpleasant, but more often it is highly offensive, decidedly penetrating and persistent, and, in many respects, the odor has been the worst obstacle to overcome in introducing petroleum products. The pioneer oil business, in New York City, for example, originally established at 184 Water Street, in 1857, was soon forced to move because the neighboring merchants complained so bitterly about the intolerable odor. To anyone who has ever encountered any of the so-called "stinking oils," such a condition of affairs is not surprising.

The most important physical character of petroleum, however, is its volatility, or its habit of passing partly into a vapor or gas when heated or when exposed to the air. It is this property which causes petroleum to become gradually denser and denser until it reaches the viscous or solid state after continued exposure. On the volatility depends the whole success of refining, in which the crude petroleum is broken up or separated into the well-known products. Refining is the real key to the modern importance of petroleum, for without such treatment the ordinary crude oil has no great commercial value except as fuel. This same property also makes petroleum a dangerous compound, since the gases derived from the crude oil are very inflammable even by themselves, and when mixed with air form an extremely explosive combination. It is this character which makes it necessary to store oil in tight vessels to prevent

loss by evaporation, while, at the same time, great precaution must be taken in guarding against fire near the wells and storage tanks.

Whatever their outward appearances, petroleums are always compounds of carbon and hydrogen, often with minor impurities giving an individual character to some particular deposit. The amount of carbon varies, as a rule, between 80 and 90 per cent, while the hydrogen makes up only about 10 to 15 per cent of the total. The most common impurities are sulphur and nitrogen, while compounds of sulphur with either carbon or hydrogen, as well as oxygen, arsenic, and phosphorous are occasionally found. Fortunately none of these impurities are ever present in very large amounts —sulphur, the most common, rarely exceeding 3 per cent; yet even this small amount of sulphur, for example, seriously impairs the value of the crude oil, by making necessary rather expensive purifying processes.

On the basis of chemical composition and character, oil men speak of petroleum as paraffin or asphalt oil, from the nature of the solids obtained in refining, or as light or heavy oil, the relative weights being expressed in degrees of the so-called Baume hydrometer scale. Thus, a heavy oil would be described as 20° Baume, or simply 20° B., while a light oil would range around 60° B., or higher. On the same scale water, the standard, ranks as 10° B., so that the oils standing high on the Baume scale are very much lighter than water, while the

heavier oils in some cases quite closely approach the density of water. As a general rule the lighter oils belong to the paraffin class and are more valuable, since they yield a larger proportion and a better quality of the higher-priced products in distillation. For special purposes, such as for fuel, however, or for the manufacture of lubricating oils, petroleum of lower or intermediate densities may be superior.

Petroleum is found to a greater or less degree in almost every country of the world; in fact, if the gaseous and solid forms of bitumen are considered as indications of the presence of petroleum, it must immediately be pronounced one of the most widely distributed of all natural substances. It also occurs in almost all ages of rocks, though the deposits which have become commercially important so far have been confined mainly to unaltered rock formations of special periods. The popular impression that petroleum is an unusual substance in nature is entirely without foundation; it is only the valuable accumulations of oil which are more or less scattered.

All the world over, attention has first been attracted to the existence of petroleum by the so-called "surface indications," such as the appearance of oil bubbles in wells and springs, or a scum of oil floating on the surface of ponds and streams. In the face of almost total ignorance, both as to the true nature of the oil and general underground conditions, it was perhaps only natural to believe

that the petroleum came from "subterranean reservoirs," "underground lakes," or "flowing streams of oil." This early belief was materially strengthened by the drilling of unproductive wells, and by the practical independence of many of the Russian wells, despite the fact that they were located relatively close together. It was supposed that non-productive wells had failed to penetrate an oil-filled cavity in the rock, while the great producers were those which happened to strike unusually large cavities or the intersection of two fissures or channels. The early accounts of petroleum wells are full of rude illustrations of such imaginary underground caverns of fantastic shape, with gas above, petroleum in the center, and water below.

Caverns and fissures may exist in the rocks beneath the surface, but the records of hundreds of thousands of wells sunk in all parts of the world do not show that petroleum deposits are necessarily associated with them. On the contrary, the drills indicate beyond question that the oil comes from porous rock formations and not from appreciable openings in the strata. It comes from the multitude of tiny spaces between the grains of the rock itself instead of from one big chamber or series of connecting chambers.

The first operators in the petroleum industry in this country also argued that the appearance of oil on the surface of streams indicated the existence of a reservoir near by, and they came to be-

lieve that the accumulations of petroleum underground coincided with depressions or valleys on the surfaee. The river flats, moreover, offered better sites for operations than did the steep slopes of neighboring hillsides, so that for a time efforts to secure oil were confined to the valleys. But the spread of operations from one place to another soon demonstrated that the oil-producing formations were of greater extent than had been imagined. Then the more far-sighted operators, or perhaps the more reekless, began to doubt that the productive area neeessarily underlay the river bottoms, and to wonder if the neighboring uplands did not also cover the hidden treasure. With this class of men, to wonder was to act. Despite the derisive name, "wildeat" applied to their ventures, many sunk wells on the uplands adjoining the produetive valleys, and proved that the oil rocks could be reached. Wildcat operations thereby became a regular part of the oil business, serving in later years to mark the limits of old, and to loeate new, oil-producing territory.

In most eases there is a comparatively large area whieh can be ealled an "oil field," the limits of which may be quite closely determined from a study of the rock formation, and by sinking an occasional test well. Within the main field there are usually several distinct areas, or "pools," from which the chief production comes, for it is very unusual to find oil in paying quantities in every part of a field. "Pools" are usually dis-

covered through surface indications or "wildcatting," though the attitude and character of the rocks may be some guide. Individual pools vary from a few acres to several hundred square miles, while the main field in which they occur may include thousands of square miles. The famous

Surface Indications: a Lake of Oil, Texas.

Spindle Top pool in Texas covered scarcely 300 acres, while the great Appalachian field covers nearly 50,000 square miles and includes a score of important pools.

The discovery of enormous quantities of petroleum far removed from coal-bearing rocks natu-

rally led to much speculation concerning its origin, since it could no longer be regarded as having a common origin with coal. In accordance with the idea of occurrence in underground chambers, it was supposed by many that the interior of the earth contained "an enormous reservoir of liquid petroleum," from which it was injected into the fissures above. This explanation was supported by the amusing argument that "petroleum could not have come from the clouds."

Another theory attempted to explain petroleum deposits as a result of volcanic action, in spite of the fact that many of the most important localities showed no signs of volcanic activity either past or present. A third hypothesis sought to include the action of the salt in the salt water which is almost universally found in association with petroleum. Another thought that petroleum was formed by the interior heat of the earth acting on the turpentine of pine trees. But of all the curious theories, propounded at one time or another, the most absurd is undoubtedly found in the idea of a Pennsylvania oil man, who believed that American petroleum was the urine of whales which had found its way from the Arctic region through subterranean passages.

This question of the origin of petroleum has occupied the attention of many of the most noted scientific men of recent generations, but even down to the present day no one has devised an explanation acceptable to all. Opinions remain still dia-

metrically opposed, with names carrying much weight arrayed on both sides. In general, the controversy is between the chemists on one hand and the geologists on the other, although there are some few of each class who must be regarded as deserters from the ranks.

The chemists believe that petroleum is of inorganic origin, or, in brief, that it is the result of instantaneous chemical reaction between carbon and hydrogen coming in contact under special conditions underground. The famous chemist Berthelot was the first to advance this idea. In his estimation an intensely heated metallic kernel in the center of the earth, carbonic acid and water coming in contact with these metals and with each other, were sufficient to produce the compounds of carbon and hydrogen found in petroleum. Most of the prominent chemists of Europe, among them the great Mendéléef, have accepted this theory with slight variations, and to justify their belief they point to very beautiful laboratory experiments in which artificial petroleum has been made.

On the other hand, a very serious objection to the chemical origin is found in the well-known fact that petroleum varies greatly both in physical and chemical character, whereas it is a fundamental principle of chemistry that a given reaction always produces the same compounds with the same character and the same composition. The adherents of the chemical theory usually try to explain away this objection in an offhand manner by say-

ing that the variations are the results of differences in the strata through which the petroleum has passed since its formation. But from evidences found in the wells it is known that there has often been very little, if any, movement of oil through the rocks, while, even if there had been such movement, the rocks do not vary enough to account entirely for such wide differences as are observed within the limits of relatively small areas.

What may be called the geological theory is based on the facts observed in the study of the different formations where oil has been found. On the basis of these facts, geologists as a body regard petroleum as of organic origin, or, in other words, as the result of slow decomposition of organic remains, animal or vegetable, which have been stored up in the rocks since the time of their formation. But, even among themselves, geologists can not come to any unanimous opinion, some holding to the idea that the organic remains were mainly derived from plant life—partly water, partly marsh, and partly land species—while others maintain just as stoutly that it was essentially animal life, much the same as is found in the ocean to-day; and many arguments are advanced to support the statements of both sides.

In the midst of all these conflicting views, it is hard to determine just which ideas are most clearly entitled to receive general acceptance. The present tendency, however, is to accept without much

question the geological theory of organic origin as being based on actual observation rather than on laboratory deductions. At the same time the number of advocates of the animal life theory is growing much more rapidly than is the number of those who hold to the plant life origin. It is not unlikely that each is partly right: that while the larger proportion of petroleum deposits have been derived from animal remains, some particular deposits, as certain light-colored oils of Pennsylvania, may be of vegetable origin. The variations in character and composition of crude petroleum are thereby readily accounted for as coming from differences in the animal or plant remains, while different degrees of heat, varying lengths of time in the process, and minor differences in rock material may have aided in determining individual characters.

With very few exceptions, the accumulation of important petroleum deposits has been controlled by the character and attitude of the strata. In fact, the occurrence of commercially valuable deposits depends fully as much on the existence of suitable conditions in the rocks as it does on the presence of an adequate original source of supply. The first requisite for accumulation is the presence of a coarse-grained, porous rock to act as a reservoir in which the oil can be stored. The usual reservoir rocks are sandstone, whence the common term "oil sands," although certain limestones, and occasionally a pudding stone or conglomerate,

serve the same purpose. This reservoir rock must be entirely covered by a fine-grained, nonporous layer, the impervious nature and absence of fractures in this second layer controlling to a very large degree the ability of the reservoir rock to retain its store of oil. Fine-grained shales are the commonest and most perfect covers for these underground reservoirs, and where such a combination of porous and nonporous strata exists in an oil-bearing region, the formation of a workable oil field usually results. In some cases, as in the limestone oils of Ohio, the reservoir rock is also the source of the supply, the oil being stored in the same strata where it was formed. In other cases, as in most of the Pennsylvania districts, where the oil is found in sandstone strata, the source of the supply is below the reservoir rock, and distinct from it.

A third factor, which has aided in most large accumulations of petroleum, is the existence of folds in the strata, arches and troughs which have resulted from the shrinking and wrinkling of the earth's crust. Practically all the great oil fields of the world show that the important deposits are found under the roofs of the arches, or anticlines as they are called, because the oil is much lighter than the salt water occurring in the same strata with it, and hence rises to the highest points possible under the arching, impervious shale cover. This anticlinal theory of occurrence has often aided materially in determining the probable limits

of a known field, and in the discovery of new fields and pools.

It may seem incredible that such enormous quantities of petroleum as have been yielded even by single wells can be secured from a rock which apparently is perfectly solid throughout. This fact more than anything else probably has fostered and kept alive the popular idea that the oil must come from fissures and cavities; for, it is argued, how else would there be room for so much oil? If a piece of the reservoir rock is examined under a strong magnifying glass, however, millions of tiny spaces appear between the different sand grains, and water will find its way through thick pieces in a comparatively short time. Such a porous, oil-bearing rock may very easily contain one tenth or one eighth of its bulk of petroleum, while some "oil sands" of the Russian fields have been calculated to contain not less than one fifth their bulk of petroleum. So innumerable are these pores in the rock that removal of the oil goes on readily enough, occasionally with enormous discharge for a time, without the existence of any definite channels to facilitate the process.

Both the storage of the oil and its discharge from the well are aided by the fact that the oil usually exists under pressure. The outward manifestation of this pressure appears most strikingly in the great flowing wells, sometimes yielding thousands of barrels of oil daily. It was originally supposed that the pressure was due to the weight

of the strata lying above the oil-bearing layers, but such an explanation is impossible. Even a com-

San Jacinto Gusher.

paratively weak rock will not crush under a weight of several hundred tons per square foot, or six

to eight times the weight of the overlying rocks, at a depth of 1,000 feet. It has also been suggested that the pressure is due to the "head" of water in the porous strata, as in artesian wells. But the facts observed in a multitude of instances do not show any parallel to the action of artesian wells, since the pressure steadily decreases almost from the moment the first discharge begins.

The most plausible explanation is that the pressure is due to imprisoned natural gas which is almost universally associated with petroleum. This theory is supported by the fact that, as the gas pressure is relieved by escape to the surface, the flowing gradually ceases, and can rarely be induced again. The greater the pressure, however, the larger the amount of oil which can be stored in a given space in the rock and the larger the yield when the reservoir is tapped by a well. This explanation readily accounts for the most phenomenal yields ever secured, without presupposing the existence of cavities of any sort.

CHAPTER II

THE ANCIENT HISTORY OF PETROLEUM

The petroleum industry as it appears to-day is distinctly a creation of modern times. Yet so old is the actual knowledge of its character and its appropriation to man's needs that no one can tell just where or when petroleum was first recognized and put to general use. It might almost be said that the history of petroleum begins with the history of mankind, for references to the members of the bitumen family are found throughout the records of past and present ages.

The chances are, however, that petroleum, or some closely related member of the bitumens, was first put to general use by the ancient civilization of western Asia, at least two or three thousand years before the beginning of the Christian era. Modern explorations in Assyria, in excavating the ruins of ancient cities have revealed fragments of brick with an asphaltlike cement still clinging to them. Old bitumen and naphtha wells are said to have been discovered in many places, while in the remains of the famous tower of Ackerouf, near the ruins of Bagdad in ancient Chaldea, bitumen-ce-

mented walls are still visible after the lapse of at least thirty-five centuries. A semifluid bitumen, probably similar to mineral pitch or naphtha, is found to have been used extensively in the construction of Babylon and Nineveh, as a cement for brick and slabs of alabaster. In the magnificent palaces and temples of these ancient cities, the wonderful mosaic pavements and beautiful inscribed panels were fastened in their places with this same material. It was also put to more humble uses in rendering water-tight cisterns and silos for grain.

Some of these structures, dating back into almost unknown antiquity, are still standing intact among the ancient ruins of western Asia. Most of the bitumens were undoubtedly obtained from local sources, which are common in many parts of Persia, Asia Minor, and surrounding districts, although some may have been derived from more distant localities. Thus, Herodotus, the Greek historian, says that the bitumen used as mortar in building the walls of Babylon was brought from the river Is, a tributary of the Euphrates.

The Egyptians also apparently made use of bitumens as early as two thousand years before Christ, for it is known that embalming of dead bodies was a common practice among them at least four thousand years ago, and many of the mummies since exhumed have been found to have the body cavities filled with an asphaltlike material. It is also said that petroleum served as a sort of glue in the man-

ufacture of the ancient papyrus, assisting materially in preventing the ravages of insects, a valuable property of petroleum which is still utilized in various ways. Just where the Egyptians secured their supplies of bitumens is not clearly recorded. Petroleum deposits are known at the present time in Egyptian territory, but about the only information concerning the supplies in ancient days is afforded by a historian of Cæsar's time, one Diodorus, who says that inhabitants of the Dead Sea region collected the asphalt cast up on the shores of the sea, and sold it in Egypt for embalming purposes.

In view of the numerous records of bitumens in the early civilization of western Asia and Egypt, it may seem strange that the Old Testament Scriptures do not mention these apparently familiar substances. It is true that in Job xxix, 6, is found the statement, "the rock poured me out rivers of oil," but beyond that statement there are no direct references to oil from the earth. This apparent discrepancy between historical and scriptural records, however, is explained by the fact that in translating the Bible, the word "salt" is said to have been used indiscriminately for common salt, nitre, and bitumen, while words translated "slime" in the common version, are translated "bitumen" in others. This other meaning of "slime" makes possible quite a different interpretation of those passages which refer to its occurrences or use. Thus, the statement that in building the Tower of Babel,

"slime had they for mortar" (Gen. xi, 3), undoubtedly refers to bitumen, which may have come from the vale of Siddim, said to be " full of slime pits " (Gen. xiv, 10). This latter reference to slime pits would also seem to indicate that the substance was used commonly enough to make its collection from special pits a more or less regular practice; a conclusion which cannot be drawn so readily from the other early accounts of its use.

The Greeks and Romans, too, were familiar with numerous occurrences of natural earth oil and its use for various purposes long before the birth of Christ, for many references to it are found in the works of their historians. In Greek literature there appears what is perhaps the first attempt to account for the origin of petroleum. Among the tales of the Argonauts, Appolonius of Rhodes recounts the fable of Prometheus, chained on the Caucasus mountains for having stolen the fire of heaven. From the day of his captivity, an eagle unceasingly devoured his liver, after which it vomited a blackish liquor called naphtha by the Greeks. This black liquor was to make Jason invulnerable in his search for the Golden Fleece. The association of localities and ideas suggests that the occurrences of oil in the Caucasus district were familiar to the Greeks, and that this fable may be regarded as their mythical conception of its origin.

The works of practically all the important Greek writers refer to bitumen deposits in various places, two of which, at least, are worthy of special men-

tion. Plutarch records the discovery of petroleum on the banks of the Oxus River by a servant of Alexander the Great, during one of the campaigns made by that famous general. Other mention is made of bitumens secured at Epidamnos, Pieria, and in the island of Zante. But most interesting of all, is the description of what was apparently a fairly regular industry in collecting petroleum from the pits of Susiana, a southern province of ancient Persia. This account by Herodotus, written about 450 B.C., says that "at Ardericca is a well that produces three different substances, for asphalt, salt, and oil are drawn up from it in the following manner. It is pumped up by means of a swipe (sweep) and, instead of a bucket, half a wine skin is attached to it. Having dipped down with the swipe, a man draws it up, and pours the contents into a reservoir, and being poured from this into another, it assumes these different forms: the asphalt and the salt immediately become solid, but the oil they collect; it is black, and emits a strong odor."

The oil described was unquestionably petroleum, and this account is entitled to the honor of being the first full description of a regular petroleum-gathering industry.

The Roman records likewise contain frequent references to bitumens of one form or another, both in Roman territory and in other countries. Early in the Christian era, the Roman army, following the practices of the people of the East, is

said to have used bituminous cements in the construction of piers for bridges. But the chief interest in the Roman accounts centers in the many references to the wells near ancient Agrigentum, the modern Girgenti, in Sicily. The oil which was secured from this locality was known as Sicilian oil, and was burned in lamps in the temple of Jupiter about the beginning of the Christian era. The story of "Sicilian Oil" affords the first recorded instance of the use of petroleum as a source of light, and from that time until the present there has been more or less constant use of Italian petroleum for lighting purposes. During the Dark Ages following the decline of the Roman Empire, the history of petroleum lapses for several centuries, but toward the end of the period reference to its use reappears in the records. For example, the oil occurring near Miano was used for light by the people of the vicinity, and as early as 1400 a concession was secured for the more extensive collection of oil from wells near that place. The celebrated petroleum from Modena was regularly worked with wells fifty to sixty feet deep before the middle of the seventeenth century, and oil from the wells at Amiano was employed in lighting the city of Genoa at the beginning of the last century.

In other European countries, too, there are records of petroleum being known and used for the past three or four hundred years. Early in the fifteenth century, the oil from the Tegern region of Bavaria was used in medicine, under the name of

St. Quirinus Oil. The "earth balsam," or "mountain balsam," as petroleum was called in Galicia, was known as early as the beginning of the sixteenth century at least, and was likewise supposed to possess special medicinal value, particularly for rheumatism and for diseases of cattle. The oldest historical records of this region show that the oil was collected in rudely timbered wells or pits, the remains of which still exist, and was used as cart grease or in the preparation of leather. Illuminating oil distilled from the crude petroleum is said to have been used in Prague as early as 1810, this making it the first case on record where a refined oil was used for lighting.

Early in the seventeenth century, the natural oil springs near Gabian, in France, were discovered, and for many years the petroleum was skimmed from the surface of the springs to be sold as "Gabian Oil," a remedy for every known ill. In fact, this spring became so famous that it attracted the people of all Languedoc, and to accommodate those who came to take the "cure," a sort of subterranean pond, with tunnels, was constructed. But a company formed later to produce oil on a large scale never succeeded.

The inhabitants of the Hanover district, in Germany, are said to have used petroleum for wagon grease and illuminating purposes since time immemorial, obtaining their supplies from deep pits, called "Fettlöcher," or "grease holes," but their crude methods could not have afforded more than

a very scant supply. It was gathered by plunging bundles of long reeds into the water. The oil adhering to these reeds, when the bundle was drawn out, could be separated from them by twisting the bundles in the same way as one would wring water from a wet cloth.

Although Great Britain contains no important petroleum deposits, attention was drawn to the bituminous rocks at a very early date, and before the end of the seventeenth century a patent had been granted for a method of making pitch, tar, and oil out of a kind of stone. Oil so made was sold as "Betton's British Oil," to cure strains and rheumatism. Thus, almost before the oil regions of America had been seen by the white men, petroleum for some purpose or other had been used in practically every country of Europe.

Among the nations of the Far East, also, the knowledge of bitumens goes far back into the ages of the dim past. The ancient records of China describe the use of natural gas for both fuel and light centuries before the beginning of the Christian era. Japanese history says that the "burning water," as petroleum was called, was first discovered and used in the Echigo district about 615 A.D. But in spite of the fact that the industry has been prosecuted almost continuously since then, the primitive methods used until recently yielded only a small quantity daily. In the islands of the East Indies petroleum deposits have only recently been developed, but the natives have known of its exist-

ence and have used it in the preparation of leather ever since the advent of Europeans in the region. Petroleum deposits in the Indian mainland, especially in British Burma, have been worked since remote antiquity, so remote, in fact, that they are often regarded as perhaps the oldest petroleum wells in the world. Here an important industry was developed before the American colonies had spread beyond the Alleghanies, and long before the beginning of the last century, oil from pits in the Irrawady valley was sent to many parts of India. Small quantities, passing under the name "Rangoon oil," occasionally even found their way to far off Europe, along with the rest of the valuable trade from the Orient.

The one locality, however, which stands out more prominently than all others in the ancient history of petroleum is the Baku district, on the shores of the Caspian Sea—the borderland between Europe and Asia. Here the distinction of great antiquity is inseparably interwoven with the story of the mystic rites of the fire worshipers, followers of Zoroaster, in the strange Parsee religion. Here, in the sacred region of the everlasting fire, it is believed that the imaginative, superstitious Oriental minds were first impressed with a phenomenon, to them supernaturally mysterious, the work of some unseen mighty spirit. Fires proceeding from the springs of natural gas are supposed to have existed for unknown ages in the Caucasus isthmus, and burning without apparent fuel, it was but an easy step for

the perplexed, half-savage people to regard fire, and especially this eternal fire, as the emblem of a beneficent god. Here, then, in sight of the eternal flames, flickering above crannies in the rock, lighted no one knows how, man, subdued with awe, came first to worship the mystery of fire. Here, for countless generations, hordes of Parsee worshipers came from Persia and far away India, from across the Caspian and the river Oxus, on pilgrimages to Baku, the holy city of fire, to their ancient stone temples and shrines, dedicated to the hidden power of flames that never ceased. Even until a generation ago, the famous temple of Surakhany welcomed its devotees from India, who still came to worship at the altars where the fires burned unquenched after thousands of years. To-day pipes have been fitted to the crannies in the rocks; the gas is used by enterprising natives to warm their huts or cook their food, and profane oil derricks dot the surface. But in spite of all the dirt and ugliness in a modern oil region, the romance of history still hovers over the place where man perhaps first learned the nature of fire, and bowed himself down in its worship.

How these everlasting fires were lighted originally must remain a mystery forever, but long ago it was recognized that there was nothing occult or mysterious in the apparent burning without fuel. Natural petroleum gases not only issued steadily from crevices in the rocks, but also, it is said, inflammable vapors were given off from the earth.

A hollow cane thrust into the ground a few inches and touched with a live coal at the top would give a steady flame, three or four of them affording heat enough to boil water and cook food. Nearly two centuries ago, the natives of the region were described as using this method, both for heat and for light in their earthen-floored houses.

The earliest stories of Baku all refer to these burning gas springs, with the strange rites of the fire worshipers, but it is not until the time of Marco Polo that the use of petroleum itself is directly mentioned. That famous explorer, visiting the Baku region in the latter part of the thirteenth century reported a great fountain of oil from which "a hundred shiploads might be taken at one time." He also says that the oil was not good to eat but was good to burn, and was used to cure diseased camels, the people coming from great distances to secure it, because there was no other oil in any of the countries round about. Polo's brief account thus implies that the oil trade must have been thoroughly established at the time of his visit, hence there is every reason to suppose that it ranks along with the Burman fields in antiquity. Polo, it is true, is often accused of telling too highly colored tales about his adventures, but fortunately, in this particular case, his statements are supported by other accounts in the succeeding centuries, wherein Baku is described as the source of oil which is "burned throughout all Persia."

Baku first came into the hands of Russia when

it was annexed from Persia by Peter the Great, some two hundred years ago. The Russians were then evidently well acquainted with the character and value of the petroleum springs, since Peter made arrangements for its regular collection and transportation to Russian towns by way of the Volga River, apparently with the intention of developing an important industry. Before anything was accomplished in this direction the region was restored to Persia, and the modern period of Russian development did not begin until the early part of the last century.

The intervening years, however, were not a period of stagnation. About the middle of the eighteenth century, England sent a representative, one John Hanway, to report on the condition of British trade in the Levant, and among his accounts there appears a very complete description of the Baku district, with the petroleum industry as it existed at that time. According to Hanway, the Persians were then securing oil in great abundance from the springs, carrying it by means of troughs into pits or reservoirs, where it was allowed to settle. Afterwards, by drawing the oil into a second reservoir, it was separated from the water and other heavy impurities with which it had issued from the springs. In its important details, therefore, this industry was exactly like that described at Ardericca, by Herodotus, two thousand years before. A regular practice was made of loading the oil in bulk in the Persian sailing craft, carry-

ing it thus to the surrounding districts, where it was used for fuel and light.

The supply was so abundant that every family, even to the poorest, could afford to use it. Besides the ordinary petroleum, or "black naphtha," as it was called, there was also a waterlike oil occurring in certain places. This purer oil was put to a variety of purposes, chief among them being its use as a cordial; as a medicine for both external and internal application; and to remove greasy spots from silk and wool, though the remedy was said to be regarded as worse than the disease on account of the abominable odor. It was also carried to India to be used in the manufacture of varnishes of "very beautiful and lasting quality."

This account by Hanway, written a little more than a century before the first well was drilled in the United States, forms one of the most interesting of all the early records of petroleum, because it suggests in one way or another the whole skeleton of the important industry existing to-day. The two chief facts which are especially significant, prophetic even, are the practice of shipment in bulk, on which the success of the modern industry largely depends, and the ability of everyone, down to the very poorest, to take advantage of its numerous uses. More curious still is the fact that the Khan of Baku enjoyed a practical monopoly of this important Caspian industry over a hundred years before the idea of a Standard Oil Company was conceived.

CHAPTER III

PAVING THE WAY FOR DRAKE'S WELL

The American petroleum industry, like all the other vast developments of this country, is largely a thing of the present rather than of the past. It finds no such records in antiquity as have been presented through the accounts of ancient authors concerning the petroleum of the Old World. But it was not long after the first settlements in the New World before the hardiest adventurers into the endless American forests were bringing back tales of the oil springs and the wonderful medicine used by the Indians.

It is often claimed that in this country the use of petroleum antedates any of the Indian tribes found by the earliest white settler. This claim arises from the fact that the oil region of Pennsylvania was found by the first English settlers to be dotted with rudely constructed pits inclosing the springs from which petroleum issued. Extreme age for the pits was indicated by trees which had sprung up on their banks and had attained a size said to be possible only as the result "of hundreds of years of growth." The pits were apparently

very old and abandoned when the first English explorers penetrated this part of the wilderness, and it has been said that the Indian legends attributed their origin to a highly civilized race which had long before become extinct.

It is still a question whether such a legend actually did exist among the Indians, or whether it came bodily from the fertile imagination of some one of the many individuals who have tried to connect the pits with the so called "mound builders." But in the minds of many who have investigated the famous "oil pits" story most thoroughly there is no longer any question that they were the works of early French explorers.

There is, however, no doubt that the use of petroleum was known among the Indians before they came in contact with either French or English. One legend says that just across the Canadian border there was a lake with a black surface—always black, and blacker by far than the shadows of the surrounding forest could have made it. Their curiosity aroused by this strange appearance, the Indians soon discovered that the deep color was caused by a greasy, strong smelling liquid forming a scum over the surface. They also observed that many animals of all kinds came to drink the water of this Black Lake, a fact which suggested the possibility of some special virtue in it. Following the example of the animals, they found as a reward for their curiosity that drinking the water was apparently beneficial for certain ail-

ments. From that time on, the legend says, the use of the oil became well-nigh universal among the Iroquois nations, and the Indian medicine men attributed to it such magic powers in all inward and outward ills that supplies were sought for in the places more remote from the now famous Black Lake.

In the southern part of New York State the Seneca tribe found petroleum in springs from which it was gathered in small quantities. Here apparently the white settlers first became acquainted with the Indian use of petroleum, and gave to it the name "Seneca oil," by which it was known for more than a century.

Turning from legendary to recorded history, the first written mention of petroleum appears in the letter of a French missionary, who describes a fountain of bitumen which he saw issuing from Lake Ontario while he was on a journey through New York districts in 1627. During subsequent years other Frenchmen reported the existence of petroleum in the Iroquois country, and on a map of the region, published in 1650, a "fountain of bitumen" is indicated near the present village of Cuba, in New York State—a strong proof that the occurrence was a matter of common knowledge. For a century or more after that time, however, the history of petroleum in this country consisted of nothing more than an occasional mention of the same regions of oil springs.

Some time during the latter part of the eigh-

teenth century the commercial spirit, which was so strong among the colonists, prompted some ingenious spirit to attempt the introduction of "Seneca oil" as a medicine among the whites. Even at that early date the methods of the modern patent medicine advertisement were apparently familiar, for in 1791 glowing accounts were published, setting forth the wonderful virtues of this natural remedy. The American soldiers, tired and sore from camping and marching in the Pennsylvania wilderness, were pictured as stopping at the springs along Oil Creek to rub their weary limbs and joints with the oil. All their fatigue disappeared as if by magic, while chronic pains and rheumatism were permanently cured. But, in spite of the amazing curative powers ascribed to it by Indian medicine men of old and by sharp-witted Yankees, petroleum does not appear to have been in very great demand as a remedy. The odor alone, to say nothing of the appearance and taste, of the crude oil would seriously restrict its popularity for such use.

It is not surprising, therefore, that the natural springs readily supplied the whole demand for medicinal purposes, but it is hard to understand why such a resourceful and ingenious people as the American colonists had made no attempt to utilize the oil for any other purpose than as a quack remedy during the century and a half since the existence of the oil springs had been well known. The only explanation which is at all satisfactory is that the oil regions were too remote, and the diffi-

culties of transportation too great, to encourage the shipment of anything but very small quantities.

The second step in the history of American petroleum came at the beginning of the nineteenth century, through the operations of the salt makers. Salt was an article of every-day need in the frontier settlements west of the Alleghanies, and at the same time the difficulties of travel across the mountains made it hard to get until local supplies were discovered. The hunters and trappers had noticed that the wild animals of all kinds frequented certain springs, the waters of which, on investigation, proved to be charged with salt. This discovery made it possible to secure a supply of salt by evaporating the natural brine, and salt making from local sources soon began to be a common practice among the settlers, especially in the vicinity of the Ohio valley. The salt makers dug wells to secure their supplies of brine, since the salt springs did not yield enough, but, unfortunately, these wells when completed were frequently found to yield also a black oily liquid having a disagreeable odor, which by its persistence interfered with the use of the brine for salt. Even this inconvenience, however, did not appear serious as long as the wells were shallow and only small quantities of oil were encountered. But as the frontier population grew, there was pressing need for larger quantities of salt, to secure which deeper and deeper wells were necessary, until, having reached

the limit of practicable digging, the idea of drilling wells was adopted.

The first real drilled well west of the Alleghanies, and very likely in the country, was bored a hundred years ago in the Kanawha valley, West Virginia, at a place known as the great Buffalo Lick or "Salt Lick." The success of this "venture" soon led to a general practice of drilling for brine in the salt regions, but, with the advent of deeper wells, the quantities of oil encountered were distinctly greater. Occasionally a single well yielded such large quantities of petroleum that it gave more oil than brine. At that time the oil not only had no value, but was actually regarded as a nuisance by the salt makers, who used all sorts of devices to get rid of it. Yet, in spite of all their efforts, as the salt industry grew, the bad wells multiplied rapidly; in some places to such an extent that the operators were forced to abandon the business. So the first quarter of the nineteenth century slipped past, with still no attempt to use this oil which was coming into the wells so abundantly and playing such havoc with the salt making.

In 1826, however, a pioneer, one Dr. Hildreth, wise beyond his generation, foresaw the proper use for this petroleum which was troubling the salt makers of eastern Ohio. He published in one of the journals of that day an article containing the significant statement that "this product offers great resources as an illuminating agent, and will certainly become of great utility in lighting the

future villages of Ohio.'' Although the salt makers continued to curse the stuff which ruined their brine, people apparently began to experiment with the oil, for a half dozen years later the same Dr. Hildreth reported that, in neighborhoods where it was abundant, petroleum was used instead of sperm oil as an illuminant and for lubricating machinery.

The common attitude toward petroleum, however, can be seen from the fact that a salt well drilled near Burkesville, in Cumberland County, Kentucky, in 1829, yielded a plentiful supply of oil for many years, but the only attempt to use it was under the name ''American Medicinal Oil,'' following the example of the historic Seneca oil. While four years later, a famous eastern chemist and geologist, visiting the Pennsylvania oil spring regions, expressed the unqualified opinion that petroleum was of no great importance, except as its existence indicated the presence of *vast beds of anthracite coal.* Luckily he lived long enough to appreciate fully the tremendous value of petroleum in itself, and to revise entirely his erroneous early ideas about its relation to coal. The second quarter of the century was nearly over and still petroleum stood on the same plane where it was fifty years before, except for the knowledge that it came abundantly from deep artesian wells in certain localities where the salt makers had operated.

A few years prior to 1850, however, there began a chain of events which marked an important ad-

vance in the development of American petroleum. It started with the effort of a Pittsburg druggist, named Samuel Kier, to extend the use of petroleum for medical purposes. Conflicting stories are told concerning how Kier came to begin this business, but the important fact is, that he used almost every known means to introduce petroleum and make it a common medical remedy. The crude oil was put up in small bottles bearing the following statement:

KIER'S
PETROLEUM OR ROCK OIL,
CELEBRATED FOR ITS WONDERFUL CURING POWER.
A NATURAL MEDICINE.
PUMPED FROM A WELL IN ALLEGHENY COUNTY, PENNSYLVANIA, 400 FEET BELOW THE SURFACE OF THE GROUND.

Startling placards and ingenious advertising devices were used to spread everywhere the story of the wonderful virtues of this natural panacea. But the taste and odor were no more agreeable in Kier's time than they had been in the days of the original Seneca oil or the American oil from Kentucky. Though the sales were raised to as much as three barrels a day, the supply greatly exceeded the demand, and the stock of bottles rapidly accumulated. Undaunted by this dismal failure of his oil as a medicine, Kier's ingenious brain quickly conceived the notion that it could be used just as well

as an illuminant, and thereupon he began to sell it as a lamp oil. The thick crude oil, however, was so full of impurities that it burned very badly and with an extremely disagreeable odor. Previous attempts had been made to use petroleum for illuminating purposes, with more or less satisfaction in sawmills and workshops, but practically all efforts at household use had been unsuccessful, because of the intolerable odor and smoke. Thus, a new obstacle impeded the success of Kier's enterprise, although the solution of the problem was even then close at hand.

About the time that Kier was trying to establish the claims of his oil as a cure-all, plants were being erected in various places for the distillation of illuminating oils from coal or shale. This industry had started in France about 1832, had quickly spread to Great Britain, and then across the ocean. In 1846, the celebrated engineer, Abraham Gesner, made an illuminating oil from coal at his home in Prince Edward Island, introducing it into the United States under the trade name "*Kerosene,*" and his example was soon followed by many others in this country. These manufactured oils met with almost immediate success, because they suffered from none of the disadvantages which prevented the general adoption of crude petroleum. Within half a dozen years from the first introduction of "kerosene," refineries for its manufacture were in operation at several places along the Atlantic coast, in Pennsylvania and in Ohio. The process of dis-

tilling these "coal oils" apparently suggested to Kier the possibility of removing the undesirable features of his oil by subjecting it to a similar treatment. At all events he tried refining the crude petroleum for illuminating purposes about 1852, and after various experiments, he finally succeeded in producing a distilled illuminating oil from petroleum which, though still far from entirely satisfactory, was a decided improvement over the crude oil.

This first illuminating oil distilled from American petroleum was used in Pittsburg, and, despite various imperfections, the consumption of Kier's "Carbon Oil" soon taxed the old salt wells to their utmost capacity, and began to suggest the desirability of securing additional supplies. The first barrel of the distilled oil sold in New York brought seventy cents a gallon, while at times the price rose as high as $2 a gallon on account of the limited amount available. Kier's experiments had revealed some of the possibilities of petroleum which could be developed through a process of distillation, but there was not yet in existence a single well which had been sunk originally to secure oil. The entire supply still had to be secured from skimming water surfaces or from wells drilled for brine, a condition of affairs which would not allow petroleum products to assume any great industrial importance. The time was now ripe, however, to usher in the final steps leading up to the birth of the petroleum industry.

Distilled coal oil was becoming decidedly popular in the Eastern cities, when Jonathan Eveleth and George H. Bissell, New York lawyers, were impressed with the possibility of securing large supplies of a similar, cheaper illuminating oil from Pennsylvania petroleum. In 1854, under the name Pennsylvania Rock Oil Company, they launched the first oil company in the United States. It was a joint stock concern, with ten thousand shares at $25 each, "to raise, procure, manufacture and sell rock oil." The entire property of the company consisted of some hundred acres on the famous "Watson's Flats," bordering Oil Creek, in Venango County, Pa. Oil springs had been known in this locality for more than two hundred years, and expert advice suggested it as the most likely region for securing a large supply of petroleum. The stock of the company was placed on the market in New York, but a good many factors prevented its ready sale. The laws of the State made any holder of stock in such a company liable for debts of the company to the full par value of shares held. Petroleum development represented a venture then entirely untried, hence regarded as involving unusual risks. At that time, too, money was scarce, and the unloading of numerous out-and-out frauds had created an attitude of suspicion and general skepticism toward anything new.

The promoters, however, believed so implicitly in their venture that, as a last resort, they secured analyses of the oil from Prof. Benjamin Silli-

man, of Yale University, one of the most noted chemists of that day. His report, voicing the opinion of a recognized and unquestioned authority, proved so favorable that several wealthy New Haven men expressed a willingness to take up the stock of the company if the company were reorganized according to the laws of Connecticut. Eveleth and Bissell had by this time become so far involved financially that any solution of their difficulties was gladly welcomed. The result was a new company, with the capital stock increased to $300,000, divided among a dozen original subscribers.

It was soon evident, however, that there was no profit to be made in operating under the old method of skimming the oil from the surface of pits and streams. Some way of securing larger quantities must be devised if the oil were to become important in domestic and industrial uses, and the company made a financial success. The suggestion which offered a solution for this problem is said to have come by a strange coincidence from one of Kier's old patent-medicine circulars bearing a picture of the artesian well from which he claimed to have secured his oil. It not only recalled the experiences of the salt makers who had encountered oil in their drilling, but it also suggested a means of tapping the subterranean reservoir from which petroleum was then supposed to come.

The New Haven company, after many delays and difficulties, succeeded in formulating a plan

for a drilled well on the Oil Creek property. For some unexplainable reason the work was placed in charge of Edwin L. Drake, then a conductor on the New York and New Haven Railroad. He left for Oil Creek in 1858, and at the time of his departure, for business purposes it is said, his employers bestowed on him the dignified title of "Colonel," by which he was known forever after. Drake immediately began to encounter difficulties. All sorts of tales are told about his constant lack of funds and the obstacles he had to overcome in getting hold of even the barest necessities to carry on operations, but, be that as it may, Drake unquestionably found the actual drilling of a well to be a serious task.

In sinking the salt wells the general practice had been to dig an open pit down to the bed rocks and then begin operations with the drilling tools. Along Oil Creek, however, the loose deposits were especially deep, and, despite all efforts, the sand was continually caving in and filling up the pit. To add to Drake's difficulties competent workmen were hard to get, and still harder to keep, on account of the demand for experienced men to drill wells for brine, where the work was easier and the pay more certain. At last, in 1859, as a reward for his perseverance, Drake succeeded in surmounting his worst obstacles. To overcome the caving of the sand he hit on the ingenious idea of driving an iron pipe down to solid rock, and then operating his boring tools through the pipe. At the same time

he succeeded in obtaining as drillman and helpers one William Smith and his sons, skilled workmen, who had had long experience in drilling salt wells, among others those from which Kier is said to have secured his oil.

Repeated attempts finally resulted in successfully forcing Drake's iron drive pipe through fifty-odd feet of sand, a depth which presented an almost impossible barrier to the old method of digging in an open pit. The drillers then commenced operations, and found that they could continue without any further trouble from caving. Concerning subsequent events every narrator has his own tale to tell. There has been in later years more or less inclination to clothe the drilling of Drake's well with as much romance as possible, but the real facts of the case are decidedly prosaic. Two or three feet a day was the best progress the drills could make, and, stopping one night with a depth of about sixty-nine feet to their credit, the men returned in the morning to find the well nearly full of oil.

Then it was that the romance came. On that day, late in August, 1859, Drake and his drillman, "Uncle Billy" Smith, had brought into existence the first well ever drilled for oil in the United States, and won for themselves everlasting fame in the annals of the petroleum industry. With one stroke they had ushered in a new era for the petroleum industry of the whole world.

CHAPTER IV

BOOM TIMES AND THE PENNSYLVANIA OIL BUBBLE

As soon as the news of Drake's success became well known, crowds of people from all sections of the country flocked to see the natural wonder. Everybody was carried away at the thought of the possibilities which it presented. Here was offered a chance to get rich quick apparently presented with a greater degree of certainty than ever before in the memory of man. It was not a business that required years of training, long experience and hard work to bring success. By the investment of a few thousand dollars the lucky operator had before him the chance of winning a fortune in the course of a few months. Vast, indeed, was the tide of humanity which surged into the oil regions in answer to these alluring prospects, bringing representatives from every state, from almost every country of the world, to try their luck in the backwoods of Pennsylvania.

Men rushed by scores and hundreds to secure plots of land in the oil region, and, in the few years following 1859, wells appeared as if by magic up and down the valleys. In this quiet farming coun-

try the plow disappeared to make way for the oil derrick. Farms were sold; old and young joined the ranks of the speculators; and poor men to-day were dreaming of millions which might be theirs to-morrow. So great was the excitement that men found no sacrifice too hard to make in order to raise funds for a lease of a plot, whereon they could sink a well, with the hope of securing a fortune in a single season.

During the first years of the oil boom the developments were confined largely to the operations of men of only moderate means. Men of wealth apparently hesitated about investing in any enterprise which had sprung into existence so suddenly, for in the early annals of the oil fields are found practically no names familiarly connected with the important affairs of that day. The pioneers in the field, like Drake himself, were largely a class of adventurers, often roving spirits who had seen much of the world and came here trusting to their wits and energy to bring them success. In the rush for leases and wells it soon became a case of the "devil take the hindmost." Ignorance of the real character of the oil and its condition of occurrence made impossible any system of development; indeed, it is doubtful if any system, however perfect, would have been followed, so great was the desire of everybody to secure a producing well before his neighbors. It was inevitable, therefore, that many failed in their first ventures and, having staked all they possessed, were reduced to ab-

ject poverty. But the hope of "striking oil" seems never to have ceased in the breasts of these gamblers with fate. Labor was in great demand, wages were good, and many a laborer rose rapidly to be a leaseholder, a well owner and, if fortunate, a man of wealth in the community.

The general appearance of the oil country was quickly changed. Derricks and engine houses replaced the humble backwoods dwellings; and a spirit of restless activity took the place of former peaceful quiet. Two years after Drake's well was completed, the valley of Oil Creek, still the only producing locality of any consequence, had undergone such a startling transformation as to be no longer recognizable as its former self. For ten miles up and down the Creek stretched continuous lines of tall derricks towering above the rude engine houses and board shanties where the operators lived. A hustling town ten miles long filled a valley where only yesterday had stretched green fields and quiet pastures.

Oil City, on the Allegheny River, at the mouth of the creek, became the natural center of the industry through its superior advantages as a shipping point. A small village proudly boasting the possession of a grist mill, iron furnace, hotel and boat landing had flourished there during the booming days of lumbering about the headwaters of the Allegheny, but with the disappearance of the logging crews the place had fallen into decay, and was almost dead and forgotten when Drake first visited

the locality. The revival beginning in 1860, however, was tremendously rapid, exceeding in a single season anything that the place had ever known before. Capitalists, speculators, prospectors, traders, laborers, gamblers, all kinds and classes of humanity poured in, until within a few years the hustling population numbered not far from ten thousand.

The impetus given by these developments along Oil Creek inflated the values of land far and near in every district suspected of being an oil-bearing locality. To the farmers of Venango County, many of whom for years had been wringing nothing more than a bare living from the soil, the oil speculations brought a golden harvest. Many a poor man found himself suddenly raised to undreamed-of wealth by the sale of a homestead which a short time before would not have found a purchaser at any price. Land in favorable locations sold readily as high as six to seven thousand dollars an acre, and single farms brought from $500,000 to $1,000,000 with additional royalties on the production of the wells.

Speculation of every possible sort among all classes went on to such an unbridled extent that it amounted to little less than sheer madness. Land speculations especially were colossal. Properties that were bought or leased were divided to be resold and sublet, oftentimes over and over again, and always at a profit, a small part of a tract not infrequently fetching a price greater than what

was originally paid for the whole lot. A plot of two acres, bearing a productive well, sold for over half a million dollars, and a farm of fifty aeres, traded originally for a yoke of oxen, was bought for $3,500, and within a year its new owners refused $4,000,000 for the same traet.

During the first years of the industry hundreds of wells were put down by poor men who, tempted by rosy visions of wealth, banded together in small parties or "associations," pooling what few dollars they possessed, or could borrow, to bear the expense of a small lease and the sinking of wells. Their total capital was often insuffieient to secure a deeent lease, but, urged on by their vain hopes of a lueky strike, they secured pitifully small fragments of land along the river front by agreeing to pay exorbitant royalties, even as high as one-half of all the oil found. Their story is the same sad tale found in the reeords of every great mining boom in history, exeept that much of the tragedy of frozen trails and sun-parched deserts is here mereifully lacking. Without means enough to seeure adequate apparatus, these poor men were forced to adopt the most primitive devices, ehiefly the method known as "kieking down," to sink their wells. This method, depending as it did entirely on man power, was utterly useless exeept in shallow workings and, as most localities yielded oil only at eonsiderable depth, the seanty means possessed by the associations soon vanished, work had to be suspended, and the leases forfeited. Many a

modest home found itself contemplating poverty and distress as a result of the irresistible lure of the oil fields and the unscrupulous, merciless dealings of the land speculators.

Drake's original well had begun to yield oil at a depth of only seventy feet, and many of the others which immediately followed it were of moderate depth, small quantities of oil being obtained by pumping. In the course of a year or two, however, the insatiable greed for oil was more and more leading the operators to the belief that, as the oil seemed to come from a depth greater than yet reached by the wells, deeper drilling would tap the main source of supply and would yield larger quantities. This theory was put to practical test in the spring of 1861, when a well was drilled to a depth of four hundred to five hundred feet to the so-called "third sand," where the greatest supply has since been found. The result was unlike anything ever before witnessed in the oil regions. Without warning the drilling tools were hurled high above the derrick, followed by a stream of oil gushing out with such force that it could not be controlled for several days. When finally subdued the well continued to discharge at the rate of hundreds of barrels a day for several months.

The effect of this first "gusher" was startling. Drake's well had created a sensation, but the striking of a well yielding daily hundreds of barrels of oil without pumping was little short of a miracle. Everybody wanted a flowing well, and a fever of

deep drilling raged through the region. Other flowing wells were struck soon after, some of them producing as high as four thousand barrels a day, or more than the earlier wells yielded in a whole year. This sudden increase in the production of oil caused the prices of oil to slump so rapidly that many owners of small pumping wells were obliged to stop all operations because they could no longer produce at a profit. But at the same time it gave a great stimulus to new ventures by holding out the prospect of still more marvelous strikes.

A year after the Oil Creek development began, the production of petroleum averaged 200 barrels a day. In January, 1861, it was 700 barrels a day, and in the spring of that year the production had again doubled as the result of many moderate-sized wells which had been opened. Then came the gushers, yielding thousands of barrels each, and jumping the total yield up to 10,000 barrels a day. Some of the oil from the earlier wells had brought as high as a dollar a gallon, and in spite of the gradual decline in price as the yield increased, there was good profit in the oil selling around twenty-five cents a gallon in the early part of 1861. But as successive gushers were struck in the summer and autumn of that year prices almost ceased to exist. Oil was as cheap as water, so cheap, in fact, that thousands of barrels were allowed to run to waste into Oil Creek, and sales were made as low as ten cents for a barrel of forty-two gallons. One man, having sold a boat

load of oil at a few cents a barrel is said to have playfully turned a stream of oil into the boat until it was swamped, because the purchaser complained that the boat as loaded was a few barrels short of the quantity for which he had paid.

Many of the early operators lost heavily on their first ventures as a result of these low prices, but the losses do not seem to have shaken their faith in the future of the oil industry. In 1861 and 1862 a number of refineries to handle the oil were built both along Oil Creek and in other parts of the country, and, when the production rose above the home demand in 1861, the dealers began to look for new markets in foreign countries. The first exports of oil consisted of 27,000 barrels sent to Europe in 1861. The quantity was so large and unexpected that the markets were glutted and the shippers suffered severely. But the way had been paved for future demands so that within a few years American petroleum was being shipped to nearly every important port in the world.

At the same time, other influences were helping to revive the industry from its marked depression. Production which had risen as high as 15,000 barrels a day during the winter and spring of 1862 to 1863 dropped rapidly to not over half that amount in 1864 as the result of the abandonment of some wells and the declining yield of others. The restriction of whaling operations, as a result of the activity of Confederate cruisers, curtailed the supply of whale oil during the war, and made

new demands for petroleum oils. Finally, the general increase of prices incident to the progress of the war put the profits up until they ranged from $3 to $10 a barrel. The industry was greatly stimulated; a new wave of speculation greater than the first swept over the oil fields, and the crest of excitement mounted higher and higher. In the midst of it all came the marvelous development at Pithole Creek, the climax of the early boom.

Commencing at Titusville in 1859, the tide of development had swept steadily over the valley of Oil Creek and along the Allegheny River above and below Oil City. Each succeeding year had brought a new crop of operators eager to invest their capital in the venture, more than filling the places of those who had become discouraged or had been unfortunate and dropped out. Up to 1864 Oil Creek had been the only important locality, and there, toward the end of that year, the production was rapidly declining. Conditions were, therefore, just right for a general stampede to any new promising field.

In the winter of 1864 and 1865, the Fraser well, flowing at the rate of 650 barrels a day, was struck in the neighboring valley of Pithole Creek. Operators from the older places thronged to the new locality, and other wells were quickly sunk, with the most gratifying success. As soon as the glowing reports of six and seven thousand barrel wells were spread abroad, unbounded excitement prevailed on

every hand, and a grand rush for Pithole began. On foot and on horseback, in wagons loaded with every conceivable article, crowds of men of every degree and profession, eager to be first among the lucky ones, filled the roads to this new field of riches. Fabulous prices were paid for the farms, and property changed hands with incredible rapidity. More than $20,000 was paid as a bonus merely for the privilege of drilling a well on a half acre lease near one producing well, but even at this price the purchaser made a handsome profit on his lease—by selling it to some one else. And so it went, feeding fuel to the flames of the oil craze in every part of the country.

A magic city sprang up on the bluff overlooking the wells. The town plat of Pithole City was not commenced until the latter part of May, 1865, and within six months a modern city having a population estimated from 10,000 to 15,000 stood where there had been a mere handful of houses a year before. Miles of streets were lined with buildings, houses, business blocks, offices, churches and hotels, and town lots were selling for $10,000 each. Palatial hotels were erected to accommodate the hordes of speculators, investors, and operators. On all sides were the gaudy signs of sudden riches easily had and easily spent.

The height of this oil madness was marked by enormous speculations and the extensive organization of so-called stock companies. In speculations on the oil exchange, many of the early operators

who had "struck it rich" saw their fortunes vanish in a night before the sharply fluctuating market, and had to begin over again, perhaps as laborer or drillman. But in the stock companies people of all classes throughout the country were fleeced of their hard-earned hoards with no chance to begin again and quickly recoup their losses. Unscrupulous promoters bought lands or secured leases which, revalued at a hundred or a thousand times their original cost, were used as the basis of a company. One Pennsylvania concern had a capital stock of $5,000,000 divided into a million shares, and several different Boston and New York companies had capitals placed well up in the millions. It is estimated that not less than a thousand of these companies were launched in the middle sixties, with stocks nominally aggregating some $600,000,000, while the actual amount of money invested was not less than $100,000,000, or more than the entire capital of the present Standard Oil Company.

The best idea of these boom concerns, and the methods by which they played on the credulity of the masses may be gained from the many satirical accounts in the sober press of the times. One of the best samples is found in a pamphlet published in Pittsburg and represented to be the prospectus of "The Munchausen Philosopher's Stone and Gull Creek Grand Consolidated Oil Company," with a capital stock of $4,000,000,000; a working capital of $37.50; paying guaranteed dividends semi-daily except Sundays. The Munchausen Company held

four tracts, the one from which the concern was named having already a shaft some 16,000,000 feet deep and "yielding cooking butter, XXX ale, turtle soup and bounty money" among other things too numerous to mention. The "Moonshine Tract" was heavily wooded; the "Ananias and Sapphira tract" was small, embracing only 65,000,000 acres, while the "China and Hades tract" was known to be "especially rich in tea!" Far fetched as this satire appears to us now, it pictures most vividly the absurdity of some of the claims set forth in the pretentious circulars of speculative companies. In actual prospectuses which have been preserved as curiosities are found the elaborate descriptions of $1,000,000 concerns with a working capital of $20,000; shares selling at a tenth, or even a fiftieth, of their par value, "for the benefit of the public"; and properties, not even known to be oil producing, guaranteed to pay at least five per cent. dividends monthly.

This speculative craze reached its height in 1865, and then the bubble burst. A variety of causes aided in precipitating the crash. The yield of the great Pithole wells fell almost to nothing; fires swept away whole blocks; the operators and the roving multitudes moved on, and in a few years Pithole City, the magnificent, was merely a memory. Its once crowded streets are now flourishing grain fields, and where the famous wells stood is no sign of oil. The great floods and fires in the spring of 1865 destroyed large amounts of oil prop-

erty throughout the region. The reaction following the close of the war brought reduced returns from the foreign shipments. Many of the fraudulent oil companies were exposed, causing suspicion to be cast even upon the most legitimate operations. A war tax of $1 per barrel for national revenue still further added to the depression. Many owners of oil property, discouraged by the outlook, were so anxious to realize on their holdings that a rapid reduction of values began.

In the face of these adverse conditions stock company after stock company failed to meet the expectations of the stockholders and lost their support. The fraudulent concerns were already rapidly going to the wall, and in the fall and winter of 1867 to 1868 the companies toppled over right and left, one after another, like a row of bricks, carrying down to ruin thousands of people whose entire capital had been invested in them. The depression in the oil regions was universal. Thousands of acres of oil lands held by the bankrupt companies, their engines, tools and machinery had to be sold by the sheriff to pay their debts. Equipment which represented an investment of $2,000 or $3,000 sold at auction for less than a hundred. The collapse of the great oil bubble was complete and disaster reigned temporarily in the oil fields.

But the stagnation was short-lived. Increased consumption and better prices abroad; improved means of transportation and storage at home; the ridiculously low prices at which engines and drill-

ing machinery could be secured in forced sales, and the decreased production owing to a suspension of operations, all combined to make the outlook brighter when the Tidioute pool in Bradford County was opened in 1868, and gave the necessary new impetus to the business. From that time the industry has increased with enormous strides, not entirely without temporary booms and reckless speculations, but never again in danger of toppling to ruin.

Such is the story of the rise and fall of the first great oil boom, and the greatest of all the oil bubbles which this country has ever seen. In a measure, however, history has repeated itself in every one of the fields discovered since Drake's first venture a half century ago. To all these places the oil derrick has come like a conquering army driving all before it. Farms, fields, orchards, gardens, dooryards, and even homesteads have been given over to the mad search for oil. In nearly all appear the same steps of progress; a lucky strike, the rush for leases, sudden wealth to the fortunate ones, boom towns, stock companies, and sooner or later the inevitable decline.

Whole volumes might be written about the unparalleled ups and downs of fortune during the great boom of the sixties. But saddest of all was the fate of Drake, the pioneer. He not only failed to take advantage of the early boom, which he himself had started, but he also neglected to patent his process of drilling, which had been adopted by

everybody and would have paid him valuable royalties. Early in the sixties he sold out all his interests in the oil fields and removed to New York, where he speedily lost all his property in speculating on the petroleum exchange. For a time he and his family were reduced to actual want, but, much to the credit of his former associates, as soon as his pitiful condition became known, a purse of several thousand dollars was collected for him. Subsequently the State of Pennsylvania granted him a pension of $1,500 a year as a mark of gratitude for the service he had rendered the country. Great indeed was the part which Drake had played in blazing the way for the modern petroleum industry. But just as a chance fate brought him, a poor conductor from a New England railroad, to be the prophet of a new era, so the same wheels of chance denied him the full fruit of his service. Nothing could be more truly typical of the oil boom.

CHAPTER V

THE PRODUCTION OF PETROLEUM

The unprecedented oil boom which marked the years following the discovery of Drake's well, and, in fact, the tremendous development of the industry later in all parts of the world, was primarily due to the introduction of new methods of obtaining crude petroleum from the underground sources. So far as can be determined every important petroleum industry has gone through the same three distinct steps in its evolution. First, the skimming of oil from the surface of streams, pools or springs; then, the advance to dug wells or pits, and finally, the advent of the modern drilled well in one form or another. The first two of these methods of securing the crude oil have been typical of the primitive industries in every country, although, in certain cases, the extensive development of dug wells must be regarded as a sort of transition stage between the ultra primitive and the truly modern.

In this country, the early skimming operations were done with a broad flat board, made thin like a knife on one edge. By moving this board forward just under the surface of the water, it soon became

covered with the thick, adhesive oil, which was removed by scraping the board on the edge of some receptacle. Variations of the same idea are found in other primitive operations, but all of these methods of working surface accumulations were capable of yielding only very small amounts, and, as man came to use petroleum more extensively, it was necessary to devise other means of getting the desired quantity.

The digging of wells to secure petroleum appears to have been first and most extensively developed in Oriental countries, especially in China, Japan, and Burma. Some of the Japanese wells in the district about Echigo, dating back into the early part of the Christian era, are said to have reached a maximum depth of 900 feet, though the majority rarely penetrated more than 200 feet. Excavation by hand to such depths in a well only a few feet square seems like a Herculean task, yet the cost is said to have been only a few hundred dollars for a well, or no more than the cost of the shallowest drilled wells of modern times. Common diggers, working for ten cents and a small portion of rice beer, per day, explain the mystery of cheapness. Under no other conditions could the industry have been carried on, for a daily yield of a few gallons, laboriously pumped by hand, was all that could be expected from these wells when completed.

The Burmese oilmen used a sort of primitive method of drilling, with the practice unchanged until comparatively recent times. As soon as the

laborers encountered solid rock in their digging, a prismlike lump of iron, weighing about 150 pounds, was suspended by a cord from a beam across the mouth of the pit. Then the cord was cut, allowing the iron to fall, the sharp edges cutting and puncturing the rock. After each fall it was necessary for a man to descend and attach a rope for hauling the iron up again. By this slow, laborious method the wells were sunk to depths of 250 or more feet, despite the fact that the presence of inflammable gases prevented the use of any artificial light, the work going on in absolute darkness, and no man being able to work more than five minutes at a time. Here, also, as in Japan, pumping by hand with a primitive form of windlass, rewarded their efforts with a few barrels of oil daily.

In these localities, as in the fields of Western Asia and Europe, the dug well—like the ordinary well for household water supplies—was extensively used, and continued to be the chief source of petroleum until comparatively late in the last century. Even now, in some of the more remote districts of Galicia, Roumania, Burma, and Japan, the primitive methods are still followed. But the widely heralded success of the American oilmen and the desire for more oil quickly placed modern tools and up-to-date machinery where tedious methods and crude implements had held sway for scores of generations.

The fact that Drake was the first in the United

States to sink a well solely to secure oil is of interest historically, yet far more significant to the petroleum industry is the fact that his was a drilled, not a dug, well. His success marks the real starting point in the development of the modern industry by preparing the way for the subsequent deep borings, without which the present enormous demands for oil could not be satisfied. It also made available for the first time a relatively economical, rapid, and efficient means of testing or prospecting for oil in localities regarded as probable oil producers.

That the artesian well was the one thing for which the petroleum industry was waiting is evident from its rapid adoption on all sides, and the gigantic expansion of operations immediately afterwards. To every place where oil is an important product, American methods, American tools, and American workmen have found their way, until, at the present time, the drilled well claims the petroleum industry of the whole world as its own.

The first step in oil production, of course, is the location of the well. Drake was guided in his choice of locality by the existence of oil springs in the vicinity, and in a vast number of oil discoveries since then, the initial well has been sunk because of the occurrence of "surface indications" of some kind. The famous Baku district, for example, is probably the most important of all the localities in the world where outward appearances indicated the presence of large underground deposits.

Many of the most valuable oil deposits, however, have been revealed by the more or less random process of "wild-catting." To call a well a "wild-cat" venture means merely that the drilling is done on untested territory, or on land not definitely known to be oil producing. The wild-cat operation is, therefore, an out-and-out gambling process, by a man who is willing to stake a few thousand dollars against heavy odds that he will find oil at some depths in a drill hole a few inches in diameter. If luck favors him, his winnings may be enormous; if he loses, his only hope is to pull up, leave the hole where his money is sunk, and move to some other place.

In the beginning of the industry, there were frequent absurd attempts to locate oil deposits by the divining rod, by clairvoyance, or through spiritualism. The divining rods used were exactly the same sort as are still heard of occasionally in locating wells to be dug for water—a simple crotch of wood, which is believed to turn over above any place where water is to be found. Using the same method for two substances as unlike as are water and oil appears ridiculous on the face of it, but the expert fakirs pretended that they could detect a difference in the action of the two substances on their magic wands. Clairvoyants and spirit mediums visited the oil regions at different times and essayed to tell where oil would be found. It is highly amusing to find them referring to "flowing streams" of oil, their supposed spirit advisers

apparently having suffered from the same degree of ignorance as did ordinary human beings of that day concerning the nature of oil deposits. Some credence was occasionally placed in these so-called manifestations of practical spiritualism, but, as might be expected, nothing of importance ever came of it.

The choosing of the actual site for a well, even in proved territory, is a ceremony which varies according to the personal whims of the operator. Every man has his own pet theory about how it should be done. One man measures distances with scrupulous accuracy, plots the ground, and gathers every available scrap of information before he is ready to set up his drill. Another drives a stake more or less at random and there begins work. Success is quite as likely to crown the efforts of one as the other, for there is no possible way of foretelling what may be found until the drill actually reaches the oil-bearing formation.

After the site of the proposed well has been selected in one way or another, the next step is the erection of a "derrick," or "rig," as the oilman calls the framework by which his string of drilling tools is handled. In its simplest form, the derrick consists merely of four strong uprights held securely in position by cross-ties and braces. For deep drilling, where a long string of tools must be raised and lowered, derricks reach a height of 70 or more feet, and are 20 feet on a side at the base.

In shallow workings, heights of not more than 30 feet are common.

As soon as the derrick is completed, and the engine installed to furnish power, actual drilling operations can be begun. The first step is the sinking of the conductor or drive pipe through the soil to bed rock: often a wooden conductor when the rock is near the surface, but always an iron drive pipe when the surface deposits are deep. Several hundred of the first wells that were sunk in this country were drilled by the process known as "kicking down," or by the use of a "spring pole." In this process a post, driven deep in the ground outside the derrick, supported a stout timber bearing the tools at one end and a weight to counterbalance them at the other end. On each side of the drill were fastened loops or "stirrups." The drillers, by placing one foot in the stirrups and "kicking," or "jumping" down, made the heavy drill strike the rock, while as soon as the men lifted their feet, the counterweight would raise the drill ready for another stroke. In the spring pole method an elastic pole securely fastened at one end was used instead of the balanced timber. Both of these methods were employed extensively in the Pennsylvania fields, but they were essentially a poor man's makeshift. They were effective only in shallow wells, and were quickly discarded when the superiority of deep borings was recognized.

At the present time there are two main systems

of drilling, depending on the form of apparatus used: the American and the Canadian, or, as they are more commonly called, the rope or cable system, and the rod system.

The drilling tools in the American system are suspended by means of a hemp rope or wire cable, which passes through a pulley wheel or block at the top of the derrick. The "string of tools," as it is usually called, is divided into two parts, the lower part giving the downward or cutting stroke, and the upper part giving an upward stroke to loosen the drill from the rock. Between these two parts come the "jars," one of the most important adjuncts of successful drilling. The jars resemble two long flat links of a chain sliding back and forth on each other with perfect ease. The lower part of the string of tools consists of the drill, or bit, the auger stem into which it fastens, and the lower half of the jars. The upper part of the string includes the other half of the jars, the sinker bar, and the rope socket. The different tools vary widely in size and weight, but, for ordinary deep drilling, the whole string will measure somewhere about 60 feet long, and weigh from 1,800 to 2,200 pounds. The auger stem and the bit usually make up more than half the total weight. If the weight of the lower half of the jars is included, it appears that approximately two thirds of the weight of the whole string is in the lower part.

During the process of drilling, the string of tools

is connected by the cable to a walking beam, operated by a small engine. At each movement of the beam, the tools rise and fall with a regular monotonous clank. On the downward stroke, the upper half of the jars slide part way down into the lower half, but as the walking beam rises, the slack is taken up, and the jars are quickly drawn out to their full length, delivering a sharp upward blow which serves to loosen the drill. The impact of the heavy drill, falling forty or more times a minute, and constantly turned by the drillman, pulverizes the rock into sand, the rate of drilling varying from a few feet to possibly a hundred feet a day, according to the nature of the rock. The process of drilling appears simple enough in principle, but in actual operation the regulation of the stroke to take the greatest advantage of the blow requires much skill on the part of the drillman, whose sole guide is the "feel" of the tools as he regulates their movement.

Besides the tools actually used in cutting the hole through the rock, the usual drilling equipment includes a great variety of accessory implements to be used in special cases: reamers to enlarge the bore holes; sand pumps and bailers to remove the powdered rock, water, and oil; and elaborate "fishing" tools to be used in case of accidents. These fishing implements especially occupy a prominent position in the drillers' equipment, since at any time a broken cable or string of tools may put an end to further work unless the well can be cleared.

By means of one or another of the fishing tools it is possible, at depths mueh over 1,000 feet, and in a hole nowhere over a foot in diameter, to cut off a broken eable, unserew a string of tools, and raise the parts one by one, or even to eut a new thread on the end of a broken tool, so that a soeket ean be serewed on it again. Frequently weeks are spent in patiently fishing for a lost string, when, without aeeidents, the entire well could be completed easily in less than a month.

The proeess of drilling, aside from oeeasional aeeidents, eonsists essentially in keeping the machinery going twenty-four hours a day. The drilling erews work in shifts of twelve hours eaeh, eaeh shift ineluding a drillman and one or more tool dressers to assist him. At varying intervals, the tools are drawn out in order to replaee the bit with a sharper one, this drawing out and returning the tools to the drill hole being the proeess where the derriek with the pulley at its top is neeessary. While the bits are being changed, a sand pump, whieh is really only a tube with a valve in the bottom, is sent down to elean out the aeeumulation of pulverized roek in the drill hole. This eable system of drilling is best suited to deep wells, and has been adopted extensively in Russia, Burma, and in most other plaees where it has been neeessary to exeeed a depth of 1,000 feet.

The Canadian, or rod, system differs from the American system prineipally in the use of slender wooden or metal rods in plaee of the cable, a sim-

ple auger, like a carpenter's auger on a large scale, instead of drills, and a different transmission of power. This system was developed to meet the conditions of the Petrolia oil regions in Ontario, where boring in the greasy clays was done with an open elay auger turned by a horse traveling in a cirele. Rods of tough, long-grained, white ash, two inches in diameter, were used originally, but in some of the plaees where the Canadian system was introdueed later it was necessary to use iron rods. The rod system is best in many places for moderate depths and where inelined strata make it extremely difficult, often impossible, to keep the drill hole straight, if the eable system is tried. An improvement on the Canadian system is the modern method of diamond drilling, as it is called, in which the drill consists of a hollow rod with a diamond or steel crown, a continuous supply of water being forced through the rod to keep the erown cool and to earry off the débris. It is a more rapid method than either of the others, and in deep drilling is regarded as cheaper in the end.

The condition of the strata in many places presents serious difficulties to all drilling operations. In the California fields, for example, slipping and caving of the highly inclined layers is a eonstant source of trouble, so that it becomes necessary to insert iron casing pipes as fast as the drill penetrates the roek. Under these conditions it sometimes takes a year to complete a well, and the cost of the casing alone is much greater than that of a

completed well in Pennsylvania. Single wells in the Coalinga field, California, where the conditions are particularly bad, have cost upward of $30,000. Similar trouble is encountered in the Russian districts, often to such an extent that wells have to be started with a drill two or more feet in diameter at the surface, in order to have the necessary room for the tools, as successively smaller casings are inserted with increasing depth.

Oil wells, in general, when completed, may be regarded as consisting of three sections: first, the surface portion in the deposits of loose gravels and clays; second, the middle portion through the different strata which usually contain more or less water; and third, the lower portion in the oil sands. The conductor or drive pipe passes through the first section. Iron casing pipe is used in the middle section to keep ground water from becoming mixed with the oil, and making the well "roiley," as the oilmen say. Originally, the so-called "seed bag" was used to close the end of this casing, the device consisting of a simple leather bag filled with dry flaxseed, slipped over the casing, and pressed down to the top of the first oil sand. The swelling of the flaxseed, as soon as it was wet, quickly filled the space between the pipe and the sides of the drill hole, effectively shutting out all water from above.

The general practice in latter years, however, has been to sink a large steel-shod, iron drive pipe down to bed rock. Drilling begins with a hole

from eight inches to a foot in diameter, extending from the bottom of the drive pipe to the bottom of the lowest water-bearing stratum. Then, by reducing the size of the bore, a beveled shoulder is made in the rock, and a casing pipe, having a collar designed to fit water-tight on the beveled surface, shuts off all the water before the lower portion of the well is drilled. Thus, the ground water is posi-

An Open Ditch Carrying Oil to an Earthen Reservoir.

tively excluded from the oil and at the same time its interference with drilling operations in the lower part of the well is lessened.

As regards depth, time to drill, cost of completion, and yield when finished, different wells, even in the same region, vary greatly. Drake's well was seventy feet deep, took a long time for completion, and yielded only a few barrels a day when done. Since then deeper drilling has been generally re-

sorted to, in order to secure as large supplies as possible. In the Baku district, for example, it has been a common custom to continue boring, even after oil is actually struck, until the oil flows from the mouth of the well; there, wells side by side vary by hundreds of feet in depth. Recent operations in this country have extended wells to depths of more than 4,000 feet, although, in such cases, the difficulties of drilling are very great, and the cost increases rapidly. Where the drilling is easy, and the depth not great, profitable wells may be completed easily in two or three weeks, at a total cost of only a few hundred dollars, as in some of the Ohio districts. In the face of natural difficulties, accidents, or the necessity of penetrating to greater depths, the cost mounts upward rapidly to as high as $30,000 or $40,000.

No less variable is the yield of different wells, ranging from the non-productive "dry" holes or "dusters" to the gigantic spouters pouring forth millions of gallons a day. On the basis of the general character of the yield, wells are divided into two classes, the flowing, spouting, or gushing wells, and the pumping wells. The character of the yields, however, does not necessarily indicate whether the venture is a profitable one. In some cases the cost of drilling is so great that a well flowing less than a hundred barrels a day would be regarded as a financial failure, while another well, much less expensive to drill, might be profitable if only a pumping well at twenty barrels a day.

The flowing or gushing wells are always regarded as lucky strikes among oilmen, partly because they usually mean exceptionally large quantities of oil, and partly because there is no cost of operating the well, as long as the oil issues from the ground of its own accord. Striking, indeed, are the scenes connected with the opening of one of these wells. The monotonous clank of the drill one minute is replaced the next by a sudden rush upward, the tools are hurled high in the air, and a stream of oil rises far above the derrick, like a gigantic geyser, deluging everything about as it falls back to earth.

Most of the important oil fields have at some time or other afforded the interesting spectacle of flowing wells, the most famous in this country being the memorable gushers of the Texas fields, which helped swell the oil boom in that state a few years ago. The Baku region, however, stands unrivaled in the number and enormous size of its fountains, some of which have burst forth with such uncontrollable violence that they have been a source of loss rather than of profit to their owners. The famous Droojba fountain, struck in 1883, spouted a mixture of oil and sand to a height of more than 200 feet, buildings near by were buried under the deluge of sand, while a broad stream of oil flowed away toward the Caspian Sea. Since then, many other still greater spouters have been developed there, shooting columns of oil to heights of 300 or 400 feet, soaking with oil every-

thing within a mile or more of the well, and belching forth as much as 6,000,000 gallons of oil daily. With such enormous quantities of oil poured out so suddenly, the greatest difficulty is often experienced in controlling the flow, and the anxious operators have often found themselves absolutely powerless until millions of gallons, worth thousands of dollars, have been lost.

When the natural flow of petroleum ceases, as a result of relieved gas pressure, and commonly in completed wells which do not flow, the practice known as "shooting" is resorted to in the hope of increasing the yield.

The early erroneous belief that petroleum occurred in fissures is supposed to have prompted the use of the "torpedo," the idea being to break up the strata around the bottom of the well, and secure the yield from as many fissures as possible. The scheme was first suggested by a Colonel Roberts, in 1862, but, for fear of the effect on the well, it was not given a trial until two or three years later, when, in a single trial, its success was immediately demonstrated. The process consists simply of discharging some powerful explosive, usually nitroglycerin, at the bottom of the well, a single charge sometimes ranging as high as 200 quarts. Shooting wells is one of the few spectacular features connected with the petroleum industry, but to the operators it is purely a matter-of-fact business proposition. The nitroglycerin, which needs but the slightest jar to explode it, is transported over the

Shooting an Oil Well.

roughest mountain roads, in padded wagons to be sure, but still in a way to appall the stoutest heart of any but the shooters themselves. Sooner or later, it is said, the majority of shooters meet violent deaths at this precarious trade. From the spectacular standpoint, the operation of shooting stands nearly on a par with the striking of a gusher. The heavy shock of the explosion shakes the earth, as in an earthquake, then the dull muffled report is followed by a jet of oil, water, and fragments of rocks, leaping a hundred feet in the air, and falling back to the earth like the outburst from some monster fountain. Shooting a well, if successful, gives an increased production for a time, though not necessarily a greater total yield. In extreme cases, particularly in wells yielding very high-grade oil, shooting may be tried three or four times, but, as a rule, with poorer success each time.

Soft strata, such as are found in some of the California fields, and about Baku, make the torpedo practically useless, hence in these fields and some other districts shooting is never employed.

From the glory of the most gigantic spouter, a gradual declining yield of the well is inevitable and, whether "shot" or not, it rapidly descends to the humdrum life of a well which must be pumped in order to produce oil. Few wells flow for more than a short time, and then pumping by some method or other must be employed as long as the total yield warrants it.

Pumping in the old days was done with a cen-

tral boiler using coal for fuel, and connected by a network of steam pipes, with an engine at each well. Now a single engine serves for dozens of wells, scattered all over a large area, and makes possible a very material saving in power. The pump itself is the perfection of simplicity; below

Storage Tank for Crude Oil.

ground a tube runs almost to the bottom of the well, with a valve near its lower end; a pump rod working up and down in the tube completes the apparatus in the well. On the surface a simple combination of two levers, called the "jack," mounted on a framework transforms the horizontal pull on the rod or cable from the engine into a vertical pull on the pump rod. The economy of

power is carried still further by pairing the wells, so that the upstroke in one coincides with the downstroke in another. In this way a hundred wells may be pumped by a single gas engine so cheaply that a well producing half a barrel a day can be operated profitably.

This business of getting the crude oil out of the ground is undoubtedly attended by more risks and uncertainties than any other phase of the entire industry. In the first place, when drilling is begun there is no certainty that it will be successful. Even when a productive well is struck, there is no possible way of knowing the extent of the supply. The story of Pithole City, and of other boom places, tells how suddenly and unexpectedly a region may "go dry." Still more vital, however, is the fact that the oil cannot be kept in storage underground, as any other mineral may be left in the mine, and be removed as it is wanted. All the wells in a locality usually draw their oil from a common source, and if any well owner stops producing, the neighboring wells will get more than their share. This condition of things explains the eagerness of each operator to drill faster and pump faster than his rivals. Whatever the price of the oil, therefore, production practically never ceases until the well is exhausted.

CHAPTER VI

THE EVOLUTION OF BULK CARRIERS

It is not unlikely that the American petroleum industry would have developed sooner if the oil regions had been in less out-of-the-way places. In fact, recent years have frequently afforded the spectacle of localities in which expansion was not possible until the necessary means of communication were afforded. The American oilmen were the first to realize that the proper solution of the transportation problems meant not only access to the most remote of the world's markets, but the practical control of the most important. This realization and the clear vision of the solution, it is true, came only as the result of experience in the early years of the industry; yet when the realization did come, the evolution of the modern transportation system was rapid.

The first shipments from Oil Creek to Pittsburg are said to have been made in five-gallon cans slung on the back of a pack horse. As soon as the important developments on Oil Creek were begun, however, overland shipment of the oil was no longer adequate or practicable. The natural solu-

tion was to ship by water down the creek to Oil City, or from Oil City, as a starting point, down the Allegheny River to Pittsburg, the nearest and most convenient distributing center. Thus there grew up an extensive system of transportation by wagons from the wells to the river, and by boats or barges down the river.

Within a short time hundreds of wagons, carrying from five to seven barrels each, were traversing the streets of the shipping points daily. The roads of the oil region originally were none too good, and now their condition became indescribable. Incessant traffic turned the soft alluvial soil of the river "bottoms" into unfathomable mud, through which the horses could barely struggle. Broken wagons and oil barrels lined the roads, and "Oil Creek mud" became a byword. Yet as slow, expensive, and unsatisfactory as it was, wagon transportation continued to monopolize the land carriage for some time.

At the shipping points along the creek the oil was transferred to flat-bottomed boats and barges in which it was conveyed to Pittsburg for distribution. Boats of all sorts and sizes were pressed into use, from the smallest wooden flatboat carrying a score of barrels up to big barges carrying a thousand barrels. On account of the shallow water in Oil Creek it was necessary to make use of the "pond freshet," as it was called, to float the loaded barges down the creek to the deeper waters of the Allegheny at Oil City. These artificial freshets

had originated with the logging crews and consisted mainly in gathering the logs behind a temporary dam, which, when removed, caused a small flood wave lasting a few hours to run downstream. In this way the logs, keeping pace with the crest of the flood, could be carried successfully across the shallow portions down to the deep water of the main stream. The oilmen borrowed this idea bodily from the lumbermen, the oil barges replacing the log drive.

It was, however, necessary for the oilmen to make previous arrangements with the mill owners, who controlled the water privileges, to let them have enough water for the freshet, several hundred dollars sometimes being paid for this accommodation. Public notice of each freshet was always given, so that as many boats as possible might be ready to take advantage of it. Sometimes as much as 20,000 barrels went down Oil Creek on a single flood wave. "Freshet Days" were regarded as general holidays by the people along the creek; everyone who could accompanied the boats to Oil City, and the gay crowds gave a decidedly festive appearance to that place. From the standpoint of the shipper, however, this method was far from satisfactory, for the freshets were almost always accompanied by accidents. Boats ran aground and others jammed behind them, the smaller ones being overridden and crushed by the larger, the losses in some cases amounting to thousands of barrels of oil.

It is estimated that no less than 1,000 boats of all kinds were used in the height of the river transportation. At first they carried oil either in barrels or in bulk, but the use of barrels was always troublesome on account of the leakage. To remedy this difficulty, the inside of the barrels was specially treated with a stiff solution of hot glue, forming a continuous lining unaffected by the oil. Even this device afforded only a partial remedy, since the small amount of water usually mixed with the oil quickly affected the glue and the leaking became as bad as before.

The steadily increasing dissatisfaction with barrel shipments soon led to the idea of carrying the oil in bulk; for a time it was done by running the oil into open barges, but this plan presented worse difficulties than the old way. Any slight rocking of the boat would set the oil in motion, and losses of whole cargoes from capsizing were frequent. When the boats did not capsize they were always leaking and the presence of water seriously impaired the quality of the oil. Because of these drawbacks to early bulk shipments, the producers usually reverted to the use of barrels when the price of oil was high, the probable loss from leakage being less risk than the chances of accident to the cargo in bulk.

The suggestion of using water-tight compartments in barges that were decked over presented a possible solution of all the earlier troubles. Such barges were introduced and, proving immediately

successful, they sealed the doom of the old-fashioned barrel shipments as far as local handling of crude petroleum was concerned.

For five or six years the teamers on land and the bargemen on the river controlled absolutely the entire system of transportation and were able to make their rates irrespective of the price of oil or the profits of the producer. The railroads center-

Tank Cars.

ing toward the oil regions, however, had long been jealously watching and coveting the enormous freight traffic moving up and down the Allegheny River between Oil Creek and Pittsburg. The great boom of Pithole City increased the already strong desires to have a share in the profitable business, and by the early part of 1866 branch lines of the main railroad systems were entering Oil City, Pithole, Titusville, and Franklin. Mile after mile was rapidly added, until within a year the oil region

had railroad conneetions in every direetion with all the leading eities of the eountry.

Rail shipments from the beginning adopted the idea of handling in bulk, being made at first in so-ealled "tank ears," whieh eonsisted of nothing more than two wooden tanks, of about forty barrels eaeh, seeurely fastened to an ordinary flat ear. Only a few years later, however, the modern eylinder tank of boiler iron easily demonstrated its superiority and entirely replaeed the older style. This entranee of the railroads in rapid sueeession, with the trains of tank ears, gave an entirely new eomplexion to the transporting end of the business. The general interests of the operators were greatly advaneed by the ease with whieh shipments eould now be made throughout a mueh wider range of territory. Bulk eargoes eould be sent to New York or Philadelphia for the export trade as readily as they eould have been shipped to Pittsburg before. Important produeers eonveniently loeated were able to have their own spur traeks and load direetly from their storage tanks. But for many operators not so favorably situated the old ineonvenienees were only slightly lessened.

The advent of the railroads, important as it was, eould not rid many of the produeers of the troublesome teamers on whom they still had to depend to earry the oil from the wells to the nearest station. Aeeording to the length of the haul, the eost of teaming ordinarily ranged as high as three or four dollars for a load of a half dozen barrels, and not

infrequently the prices were shaped to take unfair advantages of a shipper's necessities. The whole system was no longer suited to the magnitude of the petroleum interests. The new conditions of heavy production made it imperative to find some way of handling large quantities cheaply, more cheaply, in fact, than even the railroads could do it.

Ingenious minds were beginning to wonder why the oil could not be pumped through pipes extending from the wells to the shipping points just as easily as it was pumped through pipes from the wells into storage tanks. As early as 1860, General Karns, of Parkersburg, West Virginia, had proposed laying a line of six-inch pipe from Burning Springs to the Ohio River, a distance of about thirty-six miles, and letting the oil flow by gravity, but for some unknown reason the pipe was never laid and the idea was dropped. Two years later a bill to authorize the construction of a pipe line from Oil Creek to Kittanning was defeated in the Pennsylvania legislature through the vigorous lobbying of the important teaming interests in the oil regions. The same year, 1862, a man named Hutchinson constructed a small private line on the siphon principle to carry oil over a hill from his well to a local refinery, but the excessive loss by leakage at the joints of the pipe made it necessary to abandon the attempt. In 1865, however, Samuel Van Syckle built a successful line from the United States well at Pithole to Miller's Farm, on the Oil Creek railroad. He overcame the old

trouble from leakage by using carefully fitted screw sockets at the joints of the different sections of pipe. This first line was made of two-inch pipe laid on top of the ground, with three pumping engines stationed along its course of about five miles. Its capacity was limited to about eighty barrels an hour, but even that comparatively small quantity was equal to the work of about 300 teams working ten hours a day.

Immediately there was a great uproar in the region. The hundreds of teamers and the owners of teams saw at once that this new method of transportation, if allowed to live, was sure to deprive them of the profitable business which they had monopolized for five years. They also found ready sympathy outside of their own ranks, since the teamsters and boatmen made up a large proportion of the population, and every tradesman and merchant had to look to them for much of his profits. Everything possible was done to injure Van Syckle's line. The pipes were cut; storage tanks connected with the line were set on fire; and all associated with it received threats of personal violence unless pumping was discontinued. So serious was the trouble that armed patrols had to be employed to protect the pipes, and the arrest of a number of ringleaders was necessary before the disturbance could be stopped.

The pumping of oil offered such a vast improvement over the old practice of teaming that even the most hostile opponents were eventually forced to

admit its unquestioned advantages. Yet the growth of pipe lines was surprisingly slow at first, lines being laid only from the wells to the local refineries and to the main shipping points on the railroads.

The first real trunk line of pipe did not come until 1875, when a six-inch pipe was laid from the

A Main Pipe Line.

lower oil field of Butler County to Pittsburg, a distance of about forty miles. The oil men, however, were becoming more and more impressed with the possibilities of pipe-line transportation. Enthusiastic ones believed that there was no limit to the distance which oil might be pumped and, in the same year which witnessed the opening of the

trunk line to Pittsburg, the Pennsylvania Transportation Company was chartered to build a line to the seaboard, over 300 miles away. The nature of this project shows the growing trend of opinion, even though its only result was the construction of various new local lines in the oil regions.

A full dozen years after Van Syckle's first success, the railroads were still the important long-distance carriers, with the pipe lines acting as local feeders. Various traffic agreements existing at that time between the refining interests, the most important of which was the Standard Oil Company, and the leading railroads tended to perpetuate this condition. The railroads, on the one hand, struggling for their very existence, were naturally unwilling to lose their valuable oil traffic, and the Standard, on the other hand, still engaged in crushing its rivals, found its most powerful weapon of offense in the secret favors obtained from the railroads.

The most significant event in this struggle for existence was probably the building of the Tidewater Pipe Line in the late seventies, from Bradford County to Williamsport, Pennsylvania. It was built by an independent company to afford an outlet not controlled by the Standard and its railroad allies, the connection with the seaboard being made at Williamsport through the Reading Railroad, which was not a party to any of the secret rates agreements. The chief service of the Tidewater line, however, was not in reducing rates nor

in relieving temporarily the heavy burden of oppression from which many a small operator suffered. It rendered a much greater service in demonstrating the absolute feasibility of piping oil for long distances across any kind of country.

From that time on, the extension of the pipe-line system was one of the most remarkable developments in the whole growth of the industry. The first complete line to the coast was opened in 1879 from Olean, New York, to the refineries at Bayonne, N. J. Other trunk lines were soon constructed to all the important refining and shipping centers on the seaboard and on the Great Lakes, and the railroads were rapidly forced out of the business of carrying crude oil.

Pipe lines have been practically the only means used in transporting crude oil since the early eighties. Wherever the industry has spread, the pipe line has followed it, keeping pace with its growth, until now thousands of miles of pipe make a complete network throughout the fields, connecting wells to storage tanks and tanks with the great trunk lines to the important refineries. Time and again this extension of the pipe-line business has been marked by fierce wars of competition between the Standard interests and rival independent companies, and in the eastern part of the country, with but a single important exception, the Standard has always been the victor. Some idea of the development of pipe-line transportation may be had from the fact that it is now possible to

pump oil from the remotest parts of the Oklahoma fields, by way of Whiting, Ind., direct to any one of the great refineries along the Atlantic coast, the oil following a continuous line of the Standard pipes from the time it leaves the well until it enters the still at New York, Philadelphia, or Baltimore. In the Appalachian region alone, acting merely as feeders to its great trunk system, the Standard Company owns pipes enough to belt the earth.

The local lines, serving to collect oil from the wells, and deliver it into the storage tanks, are usually of small pipe, ranging from two to four inches in diameter, and are often laid directly on the surface of the ground. The trunk lines are usually underground, and consist of a special wrought-iron pipe six to twelve inches in diameter. Relay pumping stations are placed along the lines at intervals varying with the character of the country traversed. For example, on the southern pipe line from Morgantown, W. Va., to Baltimore, the first part of the route is mountainous, which means lifting the oil over many elevations. There the pumping stations are about thirty miles apart. At the eastern end, where the country is flat and practically no lifting is necessary, the interval between stations is twice as great.

The pumping station is the gateway through which the crude oil finds its way from the well out to the world. Each station is equipped with two or more tanks, like giant cheeseboxes, holding from 30,000 to 50,000 barrels; one tank receives oil

while it is being pumped out of the other, so that the stream of oil through the pipes need never cease. Powerful triple-expansion pumps capable of driving 35,000 barrels of oil a day easily

A Pumping Station.

overcome the friction of the heavy oil as it flows through the pipe. A modern station, including the tanks, costs not less than $75,000, and a trunk line of eight-inch pipe costs about $5,000 to $6,000 a mile, hence extensive pipe-line transportation is clearly a business for large capital only.

The difficulties of transporting oil by the modern pipe line are comparatively few, except in the case of some especially heavy oils, such as those found in California. The chief trouble encountered in the case of ordinary petroleum is the gradual choking of the pipes with accumulations of solid deposits and impurities from the oil. The cleaning of the pipes, however, is done quite easily by an ingenious device known as the "go devil." It is essentially a spindle so constructed that the current of oil forces it through the pipe, and at the same time causes it to rotate rapidly, a system of sharp blades scraping the sides of the pipe clean as it is sent whirling along from station to station.

The introduction and extension of pipe lines revolutionized, to a large degree, the whole aspect of the industry. The most important of these changes was in shifting the base of refining operations. For nearly twenty years after the industry began, the crude oil was refined mainly in the neighborhood of the wells, and only the valuable products were shipped any great distance. Outside the oil regions, the refineries were confined largely to the leading commercial centers, as New York, Philadelphia, Baltimore, Cleveland, and

Pittsburg, where good railroad facilities combined important local markets with easy access to outside districts.

The completion of trunk lines, together with the rapidly growing export trade, allowed the seaport refineries to expand rapidly. Refining establishments in the remote oil regions, were placed at a great disadvantage, or could not compete at all. Plant after plant was absorbed by the Standard interests, operations were discontinued, and many of the refineries sooner or later were destroyed by fire. Only a comparatively few smaller concerns were left when the transformation ended in the early eighties. From that time on, an ever-increasing proportion of the refining business has been concentrated in the extensive plants located where the two chief conditions of profitable operation are found—namely, large demands for local consumption and ease of shipment elsewhere.

Pipe lines have never been used to any important extent for the handling of refined oils, mainly because that method of transportation to any great distance is more economical than shipment by rail only when enormous quantities are to be carried daily, as in supplying big refineries with the crude oil from the wells. For this reason it is preferable to pipe the crude to the large consuming centers, refine there, and then distribute the products by other means.

Next to its influence on the location of the refining industry, the most important effect of the mod-

ern pipe-line system has been on the producers' side in the storage of oil. The early operators had to store their own oil as it came from the well, usually in wooden tanks holding a few hundred to a thousand gallons. Fires were frequent, and, though making grand spectacles to witness, the annual losses frequently mounted up into the hundreds of thousands of barrels. Hardly a thunderstorm passed over the oil regions without leaving in its path one or more flaming tanks, and general conflagrations were not infrequent. Now the producer pumps from his well to a receiving tank and sells direct from that tank, as fast as it is filled, to the pipe-line company, which usually means to the Standard Oil. The oil in the tank is measured, the valves connecting with the trunk pipe lines are opened, and the producer receives a voucher stating the quantity of oil taken. The oil so disposed of is then just as good as a bank account, so-called "pipe-line certificates" being issued against it in much the same way as a bank depositor may check out his account.

Storage is, of course, still necessary, because the production frequently exceeds the capacity of the refineries and the demands of the market. But the storage is done chiefly in enormous tank farms owned by the big oil companies, with the Standard naturally as the most important. Huge boiler-iron tanks, nearly a hundred feet in diameter, and thirty feet high, holding about 35,000 barrels, are the usual type now adopted. A single farm often

contains two or three seores of sueh tanks, with the storage eapaeity ranging up to millions of barrels. In this way the surplus production is readily taken care of, without hindering any operator from producing as fast as possible in order to keep his neighbors from getting more than their share.

The unqualified success of the pipe-line system in the United States has led to its introduetion into every important oil field in the world. The Baku operators, quick to profit by any Ameriean sueeess, introdueed pipe lines from the wells to the refineries about 1879, and, euriously enough, went through praetieally the same kind of struggle with the native teamsters as marked the laying of the first line in this eountry. In the same way in Galicia and Roumania, in Japan, in Burma, and in the Dutch East Indies the pipe line has begun to replaee the primitive methods of handling, and has put the industry on a modern basis.

The production of petroleum in this eountry has always been greater than the demands of home consumption, so that for many years much of the supply has been foreed to seek a market in foreign countries. As the foreign shipments grew, the methods of over-sea earriage began to be fully as important as the other braneh es of the transportation system. Shipments abroad for several years after export trade began, were all made in barrels, under even greater disadvantages than were entailed by the use of barrels at home.

Bulk shipments had solved the problems of do-

mestic transportation. It was, therefore, entirely logical to argue that it would serve the same purpose in the export trade. If bulk barges could

A Tank Steamer for Bulk Oil and a Lighter for Wax or Oil in Barrels.

be operated on the Allegheny River, there was no apparent reason why the same thing could not be done on a larger scale in the trade with Europe. About 1870 several wooden sailing vessels, fitted with tanks in their holds, had been tried in the

trade between this country and European ports, but with only partial sueeess. In 1872 the steamer *Vaterland* was speeially constructed to earry bulk cargoes of petroleum, but the fear that the presenee of oil in the hold would interfere with the passenger traffie prevented the tanks ever being used.

Finally, about 1879, several sailing vessels, built for the trade, successfully earried cargoes of oil in bulk to Continental ports, and marked the beginning of a new era in the marine transportation of petroleum. Other similar vessels soon followed, and beforc long tank steamers were also added to the fleet of bulk carriers. The problem of seeuring erews, however, was for a time a serious obstaele to the suecess of the steamers. Sailors, in general, regarded it as suicidal to ship on a vessel where oil and fire were companions, and many a sailor was taken aboard with his senses dulled by poor whisky. There was somc reason for this aversion to the tank steamer, it is true, for fires were frequent, both in port and on the high sea, and oeeasionally a vessel left port with a eargo of oil never to be heard from again.

As in the ease of the early pipe lines, the advantages of bulk transportation by water were far too great for any obstacle to remain long in its way. Imperfeetions in construeting the vessels were remedied, improvements were adopted, and one change after another led to the evolution of the modern steel "tanker," divided into separate eompartments by sets of longitudinal and transverse

bulkheads. Steamers, safeguarded by modern precautions, now carry millions of gallons of oil with little more danger of fire than in the case of other cargoes. Considerable care is, of course, required concerning the nature of the lights on board the vessel, the use of matches, and smoking among the

Loading a Bulk Steamer.

crew, particularly when receiving or discharging cargo, and when cleaning the tanks; but the same thing is more or less true of any kind of combustible cargo.

The tank vessel is unquestionably one of the most important inventions in the whole history of petroleum, for it alone has made it possible for Ameri-

can oils to compete in much of the world's trade against oil from other countries. Nowadays, as soon as a tanker nears port, word is sent to the refinery, and by the time the vessel is tied up at the dock the cargo of oil is all ready to be taken on board. Powerful pumps are started, and, while provisions and supplies for the voyage are being secured, the tanks are filled. Half a day suffices to put aboard a cargo that would have taken a big gang of men a week to stow in the days of shipment by barrel on the slow sailing vessels. Thirty years ago bulk carriage by sea was still in the experimental stage. Now hundreds of vessels of every description, hailing from all countries, are carrying cargoes in bulk to every corner of the world; steamers, sailing vessels, and barges transporting millions of barrels of oil annually. A multitude of stevedores and coopers have lost a profitable employment, but the advantages to the petroleum industry have been beyond measure.

The last link in the transportation of oil is the distribution of refined products to the consumer. Here again the idea of handling in bulk has been adopted quite generally both in this country and abroad. The tank car on the railroads, the chief carrier of crude oil forty years ago, is now devoted almost entirely to the shipment of the refined products, an up-to-date cylinder tank having a capacity of 6,000 to 8,000 gallons. The same economies of handling apply to the tank car as to the

tank steamer, a modern "loading rack" making it possible to fill a train of twenty cars in an hour. This rack consists merely of a pipe line from the storage tanks laid alongside the railroad tracks, with vertical branches rising up at intervals equal to the length of a tank car. Each branch pipe has

Burros Loaded with Case Oil on the Main Trail to Fez.

its own valve and an adjustable pipe long enough to reach the manhole of the car as it stands on the track. In this way one car or a score of cars can be loaded by pumping directly from the tanks where the refined oil has been stored.

In tank cars, and by tank vessels in the case of seaboard cities, the oil is carried from the main re-

fineries at New York, Philadelphia, Baltimore, Whiting, etc., to distributing points, scattered throughout the country. Tank wagons, carrying from 250 to 1,000 gallons, form the connecting links between the tank station and the retail dealer or the consumer. This wagon delivery of illuminating oils has been so generally adopted of late years in this country that practically every town having 2,000 inhabitants is now included in the system.

The plan of bulk delivery direct to the consumer has been extended enormously by American operators in recent years, until now their oil sold far away in the plains of India, or the interior of China may never have been in a package at any stage of its journey since leaving the oil well. Thousands of native boats of all sizes and descriptions carry oil in bulk or in cases to the headwaters of every important river in the Orient. Native hawkers pushing their small tanks far into the interior spread the limits of bulk shipment almost to the very doors of the great deserts of Central Asia. Tank stations and central distributing points for bulk oil now dot these countries of the far east, and appear as startling reminders of the tremendous extension of modern western ideas and methods.

The "case oil" trade is an important special phase of the distributing system. In many ways it forms the most picturesque side of the whole industry, and most strikingly illustrates the extent

to which the oil trade has surmounted every obstacle. Shipments of illuminating oil for many Oriental districts, for Africa, Latin America, in fact, for any region where local transportation facilities are not good, are usually made in the tin cans or cases holding from two to five gallons each. Oil in this form can be carried readily by coolie

Native Boat Carrying Case Oil up the Hoogly River, India.

porters, or on pack animals, under conditions where any other form of shipment is impossible, and yet where important markets exist. In the rugged parts of the West Indies, Central and South America, the patient Spanish burro takes case oil to the interior villages, plantations and mines. Donkey trains and caravans of camels receiving oil at the seacoast or along the Nile supply

the desert dwellers of Egypt and Northern Africa. Even in the wildest parts of the Sahara or the Soudan the explorer finds the inevitable tin case which once held American oil, the last outlying link in a wonderfully perfect and elaborate system.

CHAPTER VII

THE PROCESSES OF REFINING CRUDE PETROLEUM

The enormous supplies of petroleum in this country never had any great industrial value until some method of purification or refining was invented. The early attempts to use the crude oil for domestic lighting purposes in various places were invariably unsuccessful, on account of the sooty, smoking flame, and the extremely disagreeable, nauseous odor. Use as an illuminant was the only avenue of development which seemed to offer any real possibilities, but it was absolutely necessary that the quality of the oil should be improved by the removal of these objectionable features, if its use were to become general.

Purification of petroleum was done in a rough way many years before the modern process was perfected, but never on a very important scale. The medicinal oils used in European countries two centuries ago were generally subjected to some process of distillation or filtration. Refined illuminating oil from the Galician districts was introduced in the early part of the last century, and soon after that time filtering through charcoal was

tried in this country to remove the odor and improve the general appearance of the crude oil. The first important refining plant in the world, however, was probably erected in the Baku district about 1823. It consisted of an iron still having a capacity of forty buckets, and said to give about sixteen buckets of so-called "white naphtha" from each charge. This refined oil found a ready sale at the great Russian fair at Nishni Novgorod, presumably to be used in lamps.

Petroleum refining in this country began in a small way about 1855, with Kier's experiments to turn his medicinal oil to some more valuable use. The manufacture of so-called "paraffine oils" from coal and shale had increased so rapidly in the decade following 1850 that there were some fifty or sixty establishments in the eastern part of the United States when Drake's well was opened. Kier's results had already shown clearly enough that paraffine oils could be secured more easily from petroleum than from coal or shale, and more cheaply also if the supply of petroleum were large enough. The prospect of securing petroleum in large quantities by following Drake's ex-example made the entire shale oil industry totter. The owners of the refineries, many of which were then only fairly started, saw themselves facing ruin, until a simple and easy salvation appeared in converting their plants into petroleum refineries. Thus, the latter industry was able to profit imme-

diately from the existence of this large number of ready-made establishments.

Kier's first attempts at refining petroleum had given him a "carbon oil" distillate, distinctly superior to the crude oil, but far from being perfect. The strong odor still persisted and brought a storm of complaints from the consumers. General dissatisfaction was expressed also on account of the rapidity with which the oil turned black, and on account of the formation of a hard crust on the wick which interfered with the free burning of the flame. As a result the "carbon oil" gained favor slowly, despite the fact that an army of canvassers and selling agents spread over the country to boom its use. Something had to be done to place petroleum oil on as satisfactory a basis as were the shale and coal oils. Distillation alone would evidently never suffice. Chemical treatment to purify the products after distillation was tried and soon demonstrated that successive manipulations with solutions of alkali and acid would remove the chief objectionable features. These improvements, already familiar abroad, had been introduced here about the time Drake went to the oil regions. Therefore, as soon as his well was struck, the refining of petroleum was in a condition to expand and drive the shale-oil industry out of existence in short order.

The most important process in the refining of petroleum, as it is carried on to-day, consists essentially of two parts: first, heating the oil in a still until it vaporizes in the same way as boiling water

passes into steam; and second, condensing these vapors just as steam condenses on cold objects. The successful separation of the different products depends on the fact that each of the many compounds composing crude oil has its own particular boiling point, and thus allows gradual heating to

Crude Stills.

carry on the process of division, or fractional distillation, as it is called. The stills where the crude oil is heated, the condensers where the vapors of successive divisions are returned to the liquid form, and the tanks for storing the refined products, therefore, represent the important parts of the skeleton of every refinery.

The early refineries were mainly small plants

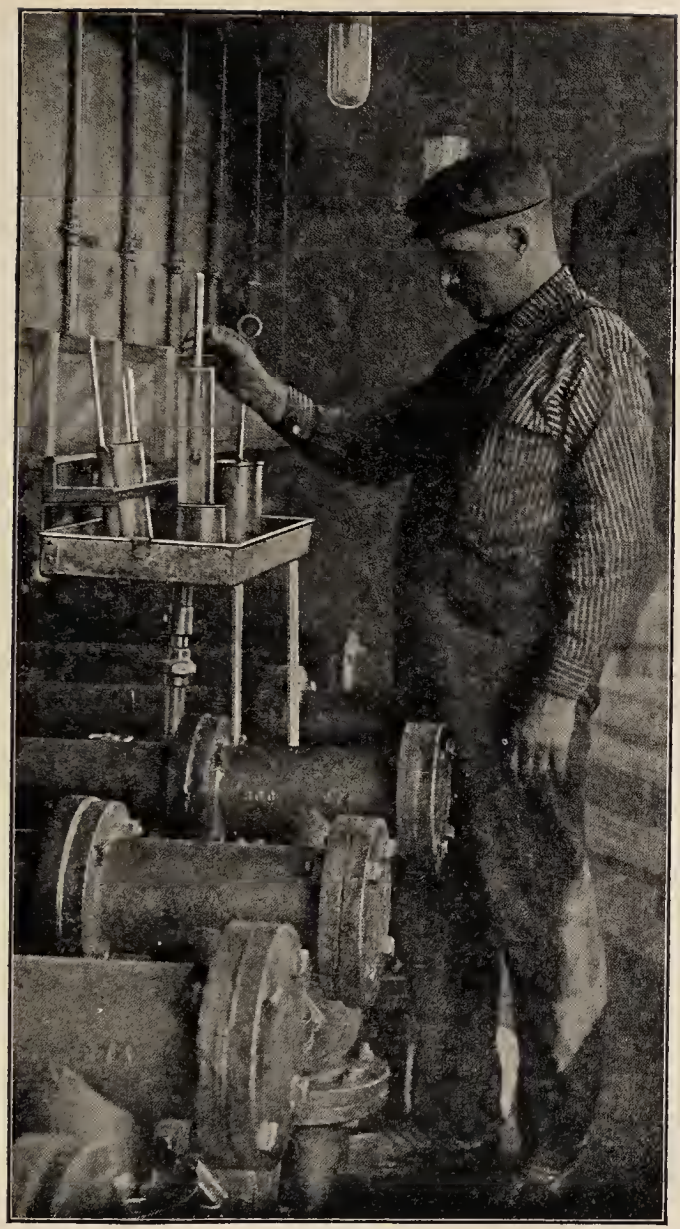
with a few vertical iron stills resembling giant cheese boxes, and having a capacity of twenty-five to seventy-five barrels each. As the industry expanded, however, and made constantly increasing demands on the capacity of the refineries, larger and larger stills were introduced. A horizontal cylinder still was found to offer various advantages over the old cheese-box style, and the cylinder form, with a capacity of about 600 barrels, is the type now generally used in this country.

Each still may have its own condenser, or several stills may be connected with a common condenser, although the former arrangement is preferable. In either case the condenser is the same, consisting of coils of three- or four-inch pipe several hundred feet long, and ordinarily kept cool by thousands of gallons of water pumped over them daily. The hot vapors entering the condenser from the still come in contact with the cold pipe and return to liquid form, in the same way as steam on a winter day will collect on the cold glass of a window and trickle down the pane in tiny streams of water. The refined product of a dozen condensers may be turned into a single receiving tank until the limit of its capacity is reached, and then other similar tanks are pressed into service.

Between the condenser and the receiving tanks, the distilled oil has to pass through the stillhouse and undergo the keen scrutiny of the stillman, on whose skill the success of the entire process depends. The condensed distillates make their en-

trance to the stillhouse through a V-shaped tube, such as are commonly inserted in drain pipes to prevent the passage of sewer gas, and which serves much the same purpose here. A vertical pipe on the condenser side of the V allows the uncondensable gases from the still, that is, those vapors which will condense only at very low temperature, either to escape into the air or to be led away to be burned under the still from which they came. The condensed distillate, now in the liquid form again, passes through the V tube and enters the stillhouse in what is called the separating box, a triangular, cast-iron affair. A glass door on one side of the box enables the stillman to watch both the color of the oil and the size of the stream as it enters the box. In this way, from the knowledge of long experience, he knows how to regulate his fires under the stills, and from occasional samples of the distillate he can determine when a different grade of oil has begun to vaporize in the still and is coming through the condenser. Shutting one valve and opening another close at hand turns the stream into a different receiving tank. So the process goes as long as separation is possible, or until some special requirements make it desirable to stop the distillation at a certain point.

The actual process of distillation consists in carefully separating the different hydrocarbon compounds which make up the crude petroleum. These "fractions," as the different compounds are called, are determined more or less arbitrarily by



The Stillman.

their weight as compared with an equal bulk of water, and by the ease with which they give off inflammable vapors.

Distillation may be done by what is known as the *intermittent process,* in which the major part of the operation is carried on in one still heated to successively higher temperatures by gradually increasing the fires beneath it. This method is most commonly used in the United States. Distillation may also be done by the *continuous process,* in which the crude oil is pumped through a series of stills, each succeeding one being heated to a constant temperature higher than that of the one preceding.

In the intermittent process, the crude oil in the still is subjected to a gradually increasing temperature, so that the different fractions pass off to the condenser in the order of their volatility. The lighter and more volatile compounds, that is, those boiling at low temperatures, are vaporized first, the heavy, less volatile compounds not appearing until the highest temperatures are reached. Different petroleums vary so widely in character, and the number of possible products is so large that each kind requires special treatment to secure the particular products for which it is best adapted. The distilling business, therefore, becomes decidedly intricate when examined in detail, and a high degree of skill must be exercised in manipulating the process so that it will yield the largest quantity and best quality of the valuable oils.

The general character of the treatment can be shown by comparing the two common processes known as "running to tar" and "running to cylinder stock." The main difference between these two processes is that the former gives the largest possible yield of illuminating oils and a small yield of heavier products for lubricating. The second process is intended to yield a maximum amount of the lubricating oils, with the illuminating oils of secondary consideration. In general, therefore, one process is the direct reverse of the other in so far as its chief object in view is concerned.

Both processes start with crude oil heated in the still, and the vapors passing off into the condenser. The most volatile of these vapors begin to appear before much of any heat is applied to the still. They can be condensed only by special processes at temperatures near the freezing point, consequently in the ordinary course of distillation they pass off into the air through the escape pipe from the condenser or are led under the still to serve as fuel. The first distillate which condenses and passes through the V tube to the stillhouse is a clear, colorless light oil, but, as the process goes on, the stream of oil entering the separating box becomes heavier, and the color gradually changes through yellow to darker shades. The stillman tests the density of the oil from time to time, and on the basis of these tests and the color, he turns the stream into different tanks, by simply closing and opening convenient valves.

The stream passing through the separating box is continuous as long as the still contains any oil which can be vaporized, hence the stillman's divisions of the stream of distillates, or his "cuts," as they are called, are an exceedingly important part of the process. The first cut is usually made when oils of the naphtha class cease to appear. The second cut is the illuminating oil. In the "running to tar" process, the method known as "cracking" is employed after about two thirds of the cut of illuminating oil has passed over, its object being to increase the proportion of illuminating oils obtained.

The exact changes which take place in the still during this "cracking" process are only partly understood. The process was discovered accidentally in 1861 by a stillman at Newark, N. J., who left his post one day after about half the contents had passed off, building a strong fire under the still to last until he returned, as he expected, a half hour later. Several hours elapsed, however, before he did return, and then, to his amazement, he found issuing from the condenser a lighter distillate than was being obtained when he left, whereas it should normally have been much heavier. Such an entirely unheard-of thing led immediately to experiments, in which it was found that a portion of the heavy distillate, normally coming through the condenser last, had condensed on the cooler upper portion of the still, and dropping back onto the highly heated liquid had encountered

a temperature hot enough to cause decomposition of some sort, so that a lighter oil was the final result. Many different devices have been invented to aid in this cracking process, and, though some refineries use it but little, cracking has been of enormous benefit in the case of certain petroleums, naturally yielding only a small percentage of kerosene, yet rich in the grades heavier than kerosene, and not heavy enough to be high quality lubricating oils. By cracking many of these intermediate grades are broken up, and become valuable illuminating oil.

After cracking has given as much kerosene as can be secured the fires are checked, and the tar process stops so far as the first still is concerned. A certain amount of thick residue or "tar" always remains in the still and must be removed before the still can receive another charge of crude oil. This tar usually goes to a second still, where further distillation gives lubricating oils, paraffin wax, and coke. The cuts of naphtha and illuminating oils are also either redistilled or subjected to further treatment to purify them and separate them into different commercial grades.

The process known as "running to cylinder stock" is essentially the same as the other up to the point where cracking would begin, except that it is usually applied to crude oils naturally adapted to the manufacture of lubricants. The important difference consists in heating the still by free superheated steam within, as well as by the usual fire

underneath the still. The presence of the steam causes a more even distribution of the heat, and more completely vaporizes the volatile lighter oils from the whole charge without having to subject it to such a high temperature. When the distillate in this process appears too heavy for kerosene, instead of the cracking treatment, a third cut, known as the "wax slop," is often made. Different methods of handling this cut yield special brands of oil for a great variety of purposes, from the headlight oil of locomotives to the thin "spindle oils" used to lubricate light machinery. The entire elimination of the cracking process leaves a greater residue in the still after the "wax slop" cut is made and this residue, known as "cylinder stock," forms the basis for the manufacture of a host of lubricating oils.

The Russian process of continuous distillation differs from the American method only in using a series of a dozen or more stills, each of which is heated to a definite steady temperature. The crude oil passing from one still to another encounters these successively higher temperatures, which correspond to the boiling points of the different petroleum products. Each still constantly gives off a distillate of uniform character, while the series of stills gives the same range of distillates as are obtained by the gradual application of increased heat in the intermittent system. The possibility of supplying the crude oil to the stills as fast as the distillates pass off results in important

economies of time, less waste of fuel, and a minimum of injury to the plant by avoiding the cooling and reheating of the still. This process, however, is not well adapted to American conditions because of differences in the nature of the crude oils, and in the products most desired. The American refiner, in general, aims to produce as much kerosene or lubricating oils as possible, whereas in Russia the enormous demand for the residuum, or *astatki* for fuel, makes it nearly as valuable as any other product. There is, therefore, little inducement to increase the yield of kerosene and reduce the quantity of residuum by employing the cracking process, which can be done only in intermittent distillation.

The first distillates obtained from the crude oil by either process usually have to be redistilled or purified before they can be used. Any sulphur which is present must be removed either in the first process or subsequently. One method makes use of copper oxide in the first condenser, or in a specially constructed still, the sulphur by chemical union being removed in the form of a copper sulphide, from which the copper can be reclaimed and used over and over. Another method makes the separation by treating the distillates successively with sulphuric acid, caustic soda, and litharge in agitator tanks built for the purpose, the removal in this case being in the form of a sulphide of lead. This treatment for sulphur is one of the most important and yet most troublesome processes of all, since the

presence of a very small percentage of sulphur imparts a highly disagreeable odor to any distillate. No product can be sold until the last trace of sulphur has been removed.

Agitators.

The naphtha distillate, where obtained in important quantities, may be roughly separated into different grades, or cuts, known as gasoline, commercial naphtha, and benzine. When the division is made by the stillman, as they come from the

condenser, washing with acid, water, caustic soda, and water again, in the metal agitators, to purify and deodorize is the only further treatment necessary before they are ready for shipment. More often, however, all the naphtha distillate goes into a single cut as it comes from the condenser, is subjected as a whole to the deodorizing and purifying treatment and is then redistilled and divided into the three fractions mentioned above. This redistillation of the naphtha is done in a special still heated by steam, and with the outlet, through which the vapors reach the condenser, rising for some distance before it actually enters the condenser coil. This arrangement is introduced to prevent any liquid from being carried over into the condenser with the gas. The condenser for the naphtha still also differs from the others in having two coils of pipe, the first of which has a "back trap," or pipe leading back to the still, so that any heavier oils present, condensing quickly, will be returned to the still. The main body of the naphtha distillate is condensed in the second coil of pipe, and is cut into standard grades by the usual separating-box method, but, in order to secure the very lightest of the products, it is necessary to use a third coil surrounded by a freezing mixture of salt and ice. The different cuts obtained from this distillation are immediately ready for use as soon as tested to prove their quality.

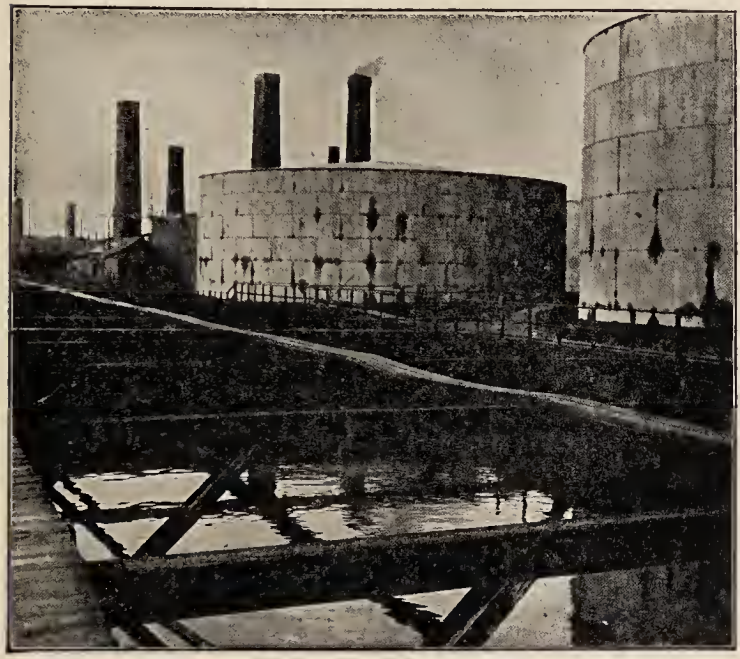
The distillate of illuminating oil, or kerosene, as

we know it, if used just as it comes from the original still, has all the disadvantages which Kier's "carbon oil" presented, charring the wicks, giving off an unpleasant odor, and rapidly turning to a dark color after standing, all owing to the presence of various impurities. The illuminating "cut," therefore, is given the same sort of purification treatment as is applied to the naphtha. Testing and grading for sale then complete the last stages in the production of kerosene.

The manufacture of lubricating oils, and paraffin or wax complete the principal processes of refining. Some lubricating oils are produced by the processes known as sunning or reducing, depending on the evaporation of the lighter products either by exposing the crude in open tanks or by gently heating it with steam. This method of treatment is said to have originated from the observation that certain oils spilled on the streams of the oil regions were thickened by evaporation, and became fit for lubricating purposes without further treatment. Experiments with different oils showed the possibility of making natural lubricators in this way from special grades of crude petroleum. So-called "sunned oils" and "reduced oils" are still to be found on the market, but by far the greater proportion of machine oils are products of distillation.

These refined lubricating oils come either from the process of "running to cylinder stock," or from the redistillation of the "wax slop," and of

the tar left in the still after cracking for kerosene is completed. These oils, in one way or another, form the basis of all grades of machine oil from the very lightest "spindle oil" to the heaviest grease. The processes of treatment differ only in



Settling Tanks for the Removal of Water and Other Impurities.

minor details from those used for the lighter oils. Different cuts are made, and these cuts, together with varying methods of purification, bleaching and filtering, determine the particular grade produced. In general, however, the redistillation of the "wax slop" cut yields the major portion of the

light and especially high-grade lubricating oils, while the heavier grades come from the cylinder stock.

Paraffin was once regarded merely as a by-product of distillation, but it is now so widely used in industrial processes that in some refineries it is fully as valuable as any of the other products. Paraffin is obtained from the redistillation of either the residuum left in the tar process after cracking is completed, or from the "wax slop" cut in the cylinder-stock process. In either case the paraffin distillation is carried on in heavy steel stills at very high temperatures. The paraffin passes off in one long stream of distillate, the latter end of which may be almost pure wax. It then undergoes the same chemical purification as the other products, the only difference being that the agitator must be heated to prevent cooling and solidification of the wax. The subsequent treatment, however, is much more complicated, consisting of a variety of steps as follows: to a settling tank where the water is removed; to a chilling tank where ammonia machines cause it to congeal and crystallize; to a filter press which forces out any oil remaining, and leaves only solid paraffin; to the melting tank to be converted into liquid paraffin again; to the bone-black filter where all color impurities are removed; and, finally, to the second chilling tank, where it is returned to the crystallized form ready for the hydraulic presses, which convert it into cakes for shipment.

From this description it appears that only two of the important products of petroleum are regularly obtained directly from the first distillation; these are the illuminating oils and the cylinder stock, and both of these have to receive additional treatment subsequently. All other products are the result of a second distillation and chemical manipulations. The percentage of the different products obtained by refining varies immensely, depending both on the original character of the crude oil and on the special aims of the individual refiner. Illuminating oils run as high as seventy-five per cent. or eighty per cent., and as low as twenty per cent. to twenty-five per cent. Lubricating oils vary from nothing up to twenty per cent. or thirty per cent., and the residuum and waste may be as high as thirty per cent. of the whole volume of crude oil. The residuum, representing the compounds which cannot be vaporized by ordinary means, is not, however, all loss, because, whether pitch, coke, or asphalt, according to the character of the crude oil, various methods of treatment and utilization are devised. Practically nothing is lost except moisture, solid impurities, and the varying amounts of uncondensed gases. Even the water used in washing the distillates is sent to huge settling tanks to recover any oil which may have been included in it.

The most volatile of these distilled oils, the naphthas, are extremely inflammable liquids, the gases from which make violently explosive combinations

when mixed with air. The presence of a very small percentage of the lighter naphtha oils in illuminating or lubricating oils is, therefore, a constant source of danger. If such oils are used explosions and fires are sure to occur. The danger is especially great in the case of naphthas present in kerosene: the most prolific cause of lamp accidents and fires in the early days of the industry. Continued complaints about the "deadly kerosene," as it was frequently called, led to the establishment of certain legal standards which all illuminating oils must meet. It has consequently become customary to subject all the distilled oils to standard tests in order to insure a uniform quality of the product. Testing is now fully as important a part of the refining process as is distillation itself, since it is the only safeguard for the interests of both producer and consumer.

The lighter oils of the naphtha group are usually tested for gravity, odor, and acid impurity. The gravity test is made with the usual Baumé hydrometer, and on the basis of this test the oils are graded for commercial purposes as gasoline, naphtha, and benzine. The test for odors is made by simply saturating a cloth with the oil, as the oil evaporates from the cloth any foreign odors are readily detected. The presence of acid is revealed by testing with litmus paper, which immediately turns red if the acid has not been entirely removed. Benzines for special purposes, as in the manufacture of paints and varnishes, also have to be free

from any of the heavier oils. The test in this case is made by soaking part of a sheet of paper in the benzine, if heavier oil, like kerosene, is present, a grease spot shows as the volatile benzine rapidly

The Lamp Test.

evaporates; otherwise the whole sheet of paper presents the same appearance.

The testing of kerosene oils is by far the most important of all, because the conditions under which it is used in ordinary lamps are especially favorable for the occurrence of explosions. Kero-

sene is tested for acid, sulphur, gravity, color, and what is known as the "fire test." Acid and gravity tests are the same as for naphthas. Color is, of course, determined by inspection, and furnishes the basis for division of the kerosene into the three grades common in this country: *water white*, which is colorless, and is the standard of American kerosene; *prime white*, of a faint yellow color; and *standard* or *standard white*, a pronounced yellow. In European countries other grades are recognized, as many as seven being commonly sold in Germany.

The fire tests, however, are the most significant since they determine the safe or unsafe character of the kerosene and the legality of its sale. Two fire tests may be used, one of them called the "flash test," determining the temperature at which the oil will give off an inflammable vapor when heated artificially, or when exposed naturally to the air. The other, known as the "burning test," determines the temperature at which the oil will take fire and burn on the surface. The latter temperature is usually from ten to forty degrees higher than the "flashing point," and, since the gravest dangers are from the generation of explosive vapors, the flash test means most.

A great number of devices have been invented for making the flash test, the essential principle of each being a closed or open cup in which the oil is heated. A common form of tester consists of a cup holding about the same amount of oil as a me-

dium-sized lamp, the cup being immersed in water and heated carefully by heating the water, on the same principle as cooking in a double boiler. The glass cover of the cup has a hole for a thermometer and another for inserting a match to ignite the vapor. Kerosene, to be safe for lighting purposes, should have a flashing point higher than any temperature which it is likely to reach under ordinary conditions. In most places a flashing point of 110° or higher is required by law. Testing, however, usually begins as soon as the thermometer shows the oil to have a temperature of about 85° or 90°, and continues at intervals of every degree or two until the insertion of the match causes the appearance of a bluish flame in the cup. As soon as this "flash" flame appears the reading of the thermometer indicates whether the oil is up to the required standard. Illuminating oils for special purposes, such as headlight oil for locomotives, signal lamps, miners lamps, and so on, frequently have to meet much higher requirements than for ordinary domestic use, but the testing process is the same.

Lubricating oils are subjected to three important tests, viscosity, fire test, and cold test, each, in a way, being of vital significance in determining the value of the oil. The first, if any, is perhaps the most important since viscosity is the most necessary quality of any lubricating fluid. The test may be made in innumerable ways, but all depend on the principle of determining the length of time

required for a given quantity of the oil to flow through a small opening. The temperature at which the test is made depends on the special use for which the individual oil is intended, ranging up as high as 212° in the case of cylinder oils for steam engines.

The fire test is necessary in the case of most machine and engine oils because the heat from friction might generate inflammable vapors if very volatile products were present. The cold test is also required to determine the temperature at which the oil would become thick and cloudy. This test is made by freezing the oil in a tube, and then as it melts, noting the temperature at which it begins to run. High-grade lubricating oils have to withstand a very wide range of temperatures; first-quality cylinder oil, for example, must have a cold test as low as 55°, and it must not flash below 550° Fahrenheit.

All these tests must be made at the refinery for each lot of distillates before they can be approved, graded, and loaded for shipment to the consumer. If any distillate does not "prove up," it has to go back for further manipulation to remedy the defects, the success or failure of the tests depending largely on the skill of the stillman in making his cuts as the distillate passes through his separating box.

In spite of its many steps and intricate processes there is nothing picturesque or spectacular in petroleum refining, unless it is in the magnitude of

the plant and the very obscurity of the many transformations going on everywhere yet entirely unseen. One refinery is essentially the same as every other save in size, and perhaps in a few minor details. At a hundred refineries from the Atlantic to the Pacific, and from the Lakes to the Gulf, the same story is repeated day after day and year after year, as the invisible stream of oil makes its journey step by step through the maze of pipes, stills, condensers, and agitators, leaving at every turn a part of its precious burden. On the one hand, the vast network of pipe lines binds the refinery to thousands of wells, scattered halfway across the continent. On the other hand, the world-wide distributing system carries the multitude of refined products into the daily life of every class of humanity.

CHAPTER VIII

PETROLEUM PRODUCTS AND THEIR USES

SOMEWHERE in the vicinity of two hundred different products can be obtained from petroleum, and the uses to which they may be put are well-nigh innumerable. The uses of the half-dozen chief products, in fact, are in themselves so varied that only the most important can be mentioned in the ordinary limit of a single chapter. In the whole realm of natural substances it would be impossible to find any other which rivals petroleum and its products in the great diversity of the needs they supply.

Petroleum first became important through the illuminating oil known nowadays by the familiar name "kerosene."

The first kerosene, however, was not a petroleum product at all; it was an illuminating oil made from coal a dozen years before the drilling of Drake's well. Kerosene was merely a trade name coined, by Abraham Gesner, from a Greek root meaning wax, thus signifying that it was a "paraffin" or "wax" oil, as most manufactured oils were then called. The first real illuminating oil

distilled from petroleum in this eountry was Kier's produet known as "earbon oil," and it was not until later that the term kerosene came to be applied generally to all petroleum illuminating oils.

The first decade of using petroleum illuminating oils forms the darkest period in the whole history of the industry. Serious aceidents and fires were daily occurrences, everywhere easting suspicion on this new lamp oil, and for a time even threatening the life of the industry. "Deadly kerosene" was then a eommon description, and more or less deserved, too, if the reeords of deaths, fire losses, and fatal accidents from lamp explosions are any indieation. But the fault was not so much in the character of the oil as it was in the character of the men selling it.

Mueh of the trouble came direetly from the fact that the kerosene was in greater demand than any of the other products. The naphthas had then praetieally no important uses, and hence sold for only a few eents a gallon. Kerosene, on the contrary, sold readily at a price from five to ten times as great. It was to be expeeted, therefore, that strong competition among the refiners would lead many, espeeially the more unserupulous ones, to turn as much of the lighter distillates as possible in with the kerosene. It was the presence of these more volatile oils which made the whole combination extremely dangerous as soon as its use in lamps was attempted.

The worst eonditions, however, were due to a

class of plain frauds who advertised recipes for so-called "secret" processes, guaranteed to render gasolene, naphtha, or benzine nonexplosive, and hence fit for use in lamps. This phase of the industry was more or less part and parcel of the oil bubble craze, in both cases a gullible public apparently having taken leave of the last trace of common sense. Peddlers and canvassers sold the "secret" recipes at a few dollars each, and about 1870 these "modified oils," just as explosive as ever, were sold throughout the country by a host of small dealers. The real character of the oils was concealed under such fancy names as "Liquid Gas," "Safety Gas," "Petroline," "Black Diamond Anchor Oil," "Sunlight Nonexplosive Burning Fluid," and so on indefinitely. The processes were so utterly ridiculous that it seems hard to believe any sane person would have put a grain of faith in them. Thus, the "Sunlight Company," of Michigan, would sell to any family the right to manufacture according to its formula for the small sum of $2, making of the recipe a rare secret indeed! The recipe given consisted in dosing the crude naphtha with an utterly ridiculous conglomeration, including alum, alcohol, cream of tartar, sal soda, two tablespoonfuls of fine table salt, oil of sassafras, gum camphor, and *one pint of raw potatoes cut fine!*

The sale of these explosive oils and the impure kerosene increased rapidly on account of the general demand for artificial lights, but the increase

of fires, explosions, accidents, and losses of life from the use of kerosene lamps steadily kept pace with the greater use. "Deadly Kerosene" was getting in its work not only here but abroad as well, and pamphlets illuminated with skull and cross bones were circulated, denouncing the "fatal liquid." Public indignation mounted high, and constant agitation of the subject soon brought material results in the form of legal restrictions to which all illuminating oils must conform.

Other factors also aided in removing the stigma which has been associated with the name of kerosene. The lighter oils were coming to have a value of their own, and the price of kerosene was somewhat lower, so that, with less difference between the prices of the two products, there was no longer such strong temptation to mix naphtha with kerosene. Processes of distillation had been materially perfected, and the separation of naphtha from kerosene could be made more accurately. Lamps, also, underwent distinct improvements with the introduction of the familiar Duplex and Rochester burners, while various safety appliances minimized the danger of fire if the lamps were accidentally tipped over. Finally, the elimination of much of the competition in refining brought with it a higher standard of quality through the desire to remove all grounds for complaint, and to extend thereby the popularity and sale of the oil.

At the present time American kerosene is used the world over without a thought of danger, and

fires or explosions traceable to its use are few indeed. Where such accidents do occur, they are more often the result of carelessness in handling lamps or of imperfections in the lamps themselves. If the fault is proved to lie in the oil, every effort is made to correct immediately the imperfections in manufacture. The reward of this improvement is found in the practical monopoly which kerosene

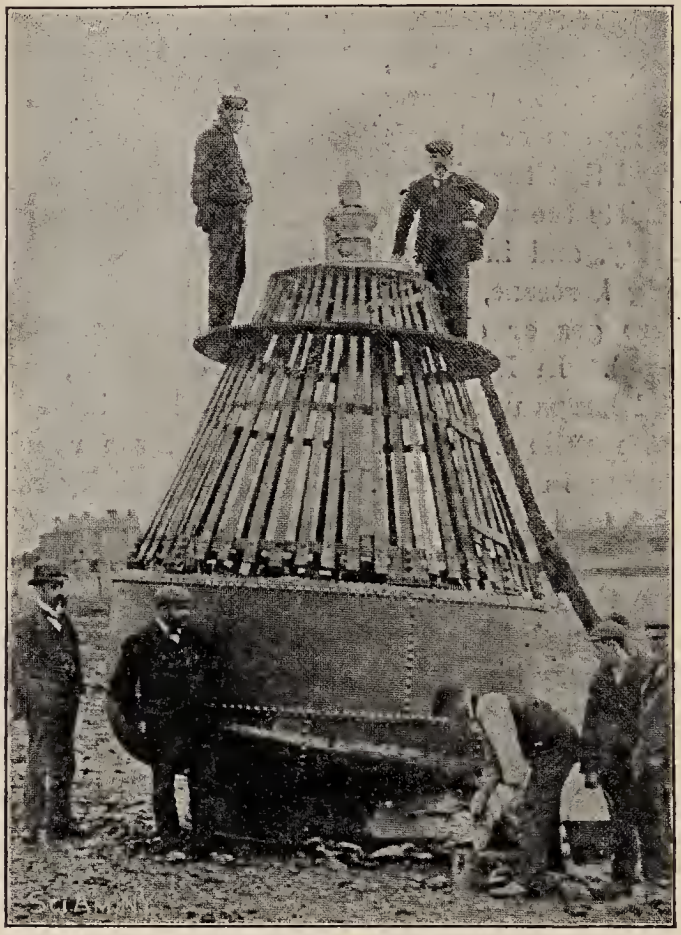
The Old and the New Lamps in China.

enjoys to-day in the field of illuminating oils. Rape seed, sesamum, mutton fat, whale oil, tallow and sperm candles, coal oil and shale oil have all been forced far into the background by the superior qualities of modern kerosene. Kerosene in an ordinary cheap lamp will give more light and better light than half a dozen of the best sperm candles at a cost of only a fraction of a cent an hour. It would be impossible to calculate the

value of the introduction of this cheap and convenient light to the world at large. It has been unquestionably one of the greatest of all modern agents of civilization.

At the present time, of course, the use of illuminating oil in numerous places has been crowded out by gas or electricity, but it must not be assumed that the oil lamp is disappearing. In rural districts the world over its use is increasing enormously, and in some cities modern "arc lamps," using kerosene, are now actually being installed where gas or electricity has been formerly employed. In Russia and Sweden, especially, powerful lamps using petroleum oil and an incandescent mantle of the Welsbach type, are rapidly growing in popularity. Gas and electricity need plants and attendants for their manufacture. The petroleum arc lamp needs only compressed air to force the oil under pressure into the orifice where it is burned. This pressure may be furnished by an ordinary bicycle pump. Lamps of 1,500 candle power have proved entirely successful—a powerful lamp of this type having been installed in one of the lighthouses at Alexandria, Egypt. For the same intensity the oil arc lamp is cheaper than either gas or electricity, costing about two cents per hour for a lamp of 800 candle power, as against two and a half cents for gas, and six and a half cents for electricity. The oil lamp has, also, the greatly superior advantage of being available where gas and electricity are not. For this reason

the new oil lamp promises to make petroleum, as an illuminant, more important than ever.



A Petroleum Buoy.

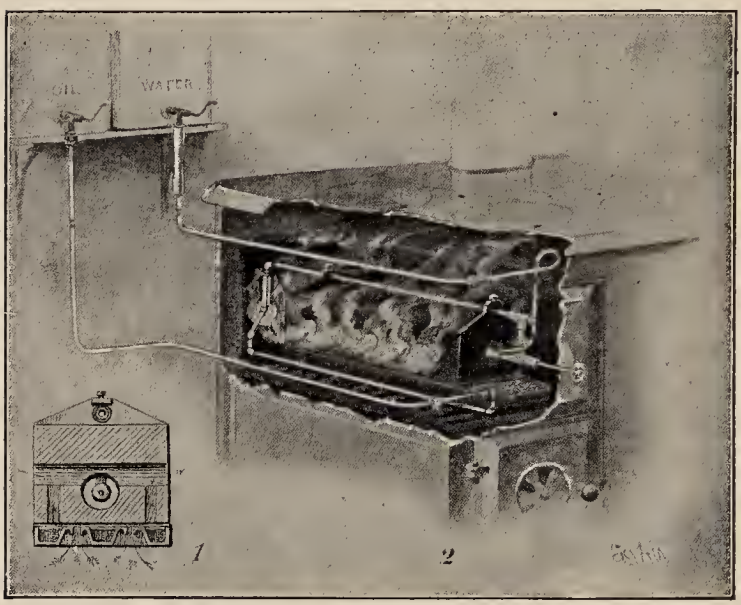
Petroleum products, aside from kerosene, also find some use in illuminating purposes, but on a

far less important scale. In the process known as the manufacture of air gas, or carbureted air, some one of the lighter distillates, usually gasoline, is employed. Crude petroleum, the so-called gas oil from the tar still, or some other petroleum products are also used to the extent of millions of barrels a year, in enriching coal gas and water gas, while to a less degree they are used to make oil gas directly. Oil gas is used widely in lights for buoys at sea, in lighthouses, and in railroad trains, the superior advantage lying in the ease of compression without impairing the quality. The familiar Pintsch system of lights, generally found in the better class of railway cars in this country, utilizes oil gas.

The use of petroleum fuel is a close rival of kerosene in importance. In one form or other—crude, refined oils, or residuum—vast quantities are burned the world over, and every year the consumption for locomotives, steamers, stationary engines, and industrial purposes is greater than before. These petroleum fuels perform an invaluable service, especially in countries where other forms of fuel are not abundant or not readily secured. Thus, in Russia and all Western Asia, in the southwestern part of the United States, and along the Pacific coast of both North and South America, petroleum fuel supplies a long-felt want. Even in countries where other fuel is abundant, easily secured, and relatively cheap, the petroleum stove and the gasoline or naphtha engines meet a

multitude of demands which could not be supplied so conveniently and satisfactorily in any other way.

Gasoline or naphtha and kerosene find a wide use in "oil stoves" of many sorts for domestic pur-



Oil Burner in Ordinary Range.

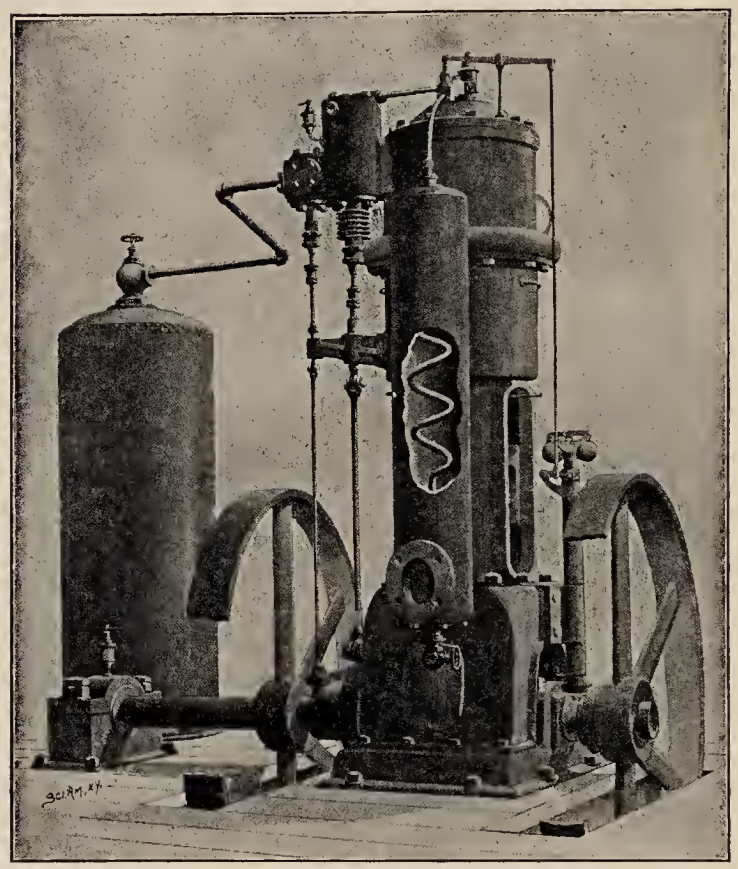
poses, principally for heating and cooking, the so-called gas stove or "blue flame" stove, being unrivaled where economy of time, space, fuel cost, and maximum results are desired. Blast lamps of all kinds, particularly for plumbers' work and similar purposes, quickly secure a high degree of heat by burning one of the lighter petroleum oils.

The crude oil is used extensively in metallurgical process, in smelting and refining, in glass factories, in burning bricks and lime, in smithy fires, and many other industrial establishments. Only recently one of the largest copper companies in Mexico has signed a contract calling for the delivery of several million barrels of fuel oil to their refinery during the course of the next three years.

From the industrial standpoint, the introduction of oil fuel has been of tremendous importance where coal was hard to get. In the Volga districts of Russia hundreds of manufacturing establishments have been located solely with reference to this supply of fuel. California industries have been stimulated by the local supply of cheap oil, where formerly all coal had to be imported, and, in South America, oil has been the salvation of the nitrate industry. The greatest of all the uses for petroleum for fuel is as a source of motive power, either as a substitute for coal in generating steam or as direct power in the gasoline or "naphtha" engine. The power in the former case depends on the superior heat-generating capacity of petroleum—crude, residuum, or fuel oil—as the case may be, while the latter utilizes the explosive nature of petroleum vapor when mixed with air.

Beginning about 1860, experiments with crude petroleum or residuum as fuel were carried on almost simultaneously in Russia, France, England, and the United States, many devices being tried to facilitate burning of the oil in a fire box similar

to that used for coal. Open pans and steplike series of grates and griddles, over which the oil flowed, gave fair results, but an Englishman's ex-



Fuel Oil Engine.

periments with a nozzle sprinkler for introducing the oil into the furnace in a jet of spray marked the real beginning of success. The old forms of

oil furnace were rapidly displaced, the spray and jet being universally recognized as the only efficient burner. Improvements in the details of the burner have been introduced from time to time, but the basic principle has remained practically unchanged since the first patent was granted in 1865.

The oil burner of to-day is essentially a simple affair. A jet of steam or compressed air from an injector drives the oil in the form of spray into the fire box, where air enough is supplied for combustion. In some burners a second jet of steam entering the fire box at one side is directed across the current of sprayed oil so that it is spread out to a greater heating surface.

The mechanical perfection of the oil burner quickly led to the adoption of petroleum fuel in many European countries, especially for use in locomotives and steam vessels, while in Russia great numbers of industrial establishments followed suit. At first the Russian fields were the chief sources of oil fuel supplies, and the enormous home consumption, coupled with the poor transportation facilities, interfered with the proper expansion of its uses. But the later expansions of the industry in the Russian and European fields generally and the discoveries of great quantities of low-grade oils, more valuable for fuel than for anything else, in Texas, California, and Borneo, acted as a decided stimulus on the fuel-oil trade.

Oil-burning locomotives are now used in all parts of the world, and are increasing in number yearly. On the Russian railways, the *astatki* or residuum has largely replaced all solid fuels. In South Africa the development of modern means of transportation was greatly retarded by the difficulty of securing fuel until oil fuel presented a means of salvation. In Peru petroleum fuel has performed a service for the railroads similar to its service in the nitrate fields of the Chilean deserts. In Persia the success of the new road to Bagdad hinges largely on the available supply of oil for fuel. There is a good reason for this importance of liquid fuel in locomotives, for it is said that, with a locomotive in good order and handled by a skillful driver, two tons of petroleum are equal to three tons of the best quality of coal.

The adaptation of oil fuel to locomotives was naturally accompanied by similar experiments on steam vessels. Since 1870 steamboats on the Caspian have used oil fuel almost entirely, and its adoption for both merchant and naval vessels has gradually spread to all the important maritime countries of the world. Two-score or more of the vessels in the fleet of the Shell Transport and Trading Company, an English concern, use petroleum exclusively with unqualified success and valuable economies. All local vessels on the California coast, and many of the large ocean-going steamers sailing from San Francisco, burn California petroleum with the best of results; nearly a hundred

and fifty vessels of all classes from that port are now fitted with oil burners. Important steamship lines, such as the North German Lloyd, Hamburg-American, and China Mutual, have already introduced petroleum into their fleets either as an auxiliary or as the sole fuel. As an auxiliary fuel it has also been adopted in our own navy and in the navies of the principal countries of Europe, the great advantage being that, in case of emergency, it gives a means of suddenly increasing the fires and using full steam almost immediately, simply by turning the oil into the injectors. Many of the newer battle ships, therefore, are fitted with furnaces to use both coal and oil. But the greatest triumph of all is in the choice of oil-burning furnaces for the new English destroyer, *The Swift*, recently launched and claimed to be the fastest craft in the world. Believing that oil fuel is to be much more important for naval purposes in the future, the British Government has sent two experts to examine the Canadian oil fields with reference to their capability of furnishing oil for the British navy. Great Britain desires to control her own supply of fuel oil, to guard against possible trouble in securing it in time of war.

The advantages of petroleum over coal as a fuel are almost innumerable. First, and most valuable of all, is its greater heating power, weight for weight, giving from thirty to fifty per cent more steam with the proper burners; two tons of oil are usually considered to be the equivalent of three

tons of coal. For the same power oil occupies less space; thirty-six cubic feet of oil being equivalent to some sixty cubic feet of coal.

Oil is easier to handle and easier to transport; a locomotive using oil can take on 150 gallons in a minute while making an ordinary stop at a station, and a vessel in a port or at sea can be resupplied in half the time necessary for coaling operations, without dirt or difficulty. In the use of oil there is no dirt or dust, practically no smoke, no ashes or clinkers to be removed, no big force of stokers necessary, no sparks to set fires. Oil can be lighted almost instantly and is under perfect regulation; a simple turn of the oil valve bringing response to any demands, while as soon as power is no longer needed the oil is shut off and the expense stops. The economy in this virtue is tremendous, especially in locomotives where starting and stopping give constantly varying demands on the fuel required.

The chief difficulty in the way of the general use of oil fuel on board vessels is found in the uncertainty of securing supplies where wanted. Coaling stations are located in every quarter of the earth, but the places where fuel oil can be had are still few and widely scattered. Therefore, until the storage of supplies becomes general at the important ports of the world, the adoption of oil as the only fuel on naval stations would entail too many risks, since the supply might be cut off in time of war. In the case of merchant vessels ply-

ing between definite ports, this objection does not present any serious obstacle, and the many advantages of oil fuel are rapidly being put to practical use in vessels of every description.

The most widespread use of petroleum as fuel, however, is not in locomotives nor steamers, but in the gasoline engine, which, in its varying forms, has been adapted to practically every namable industrial process requiring mechanical power. The term "gas engine" is commonly applied indiscrimi-

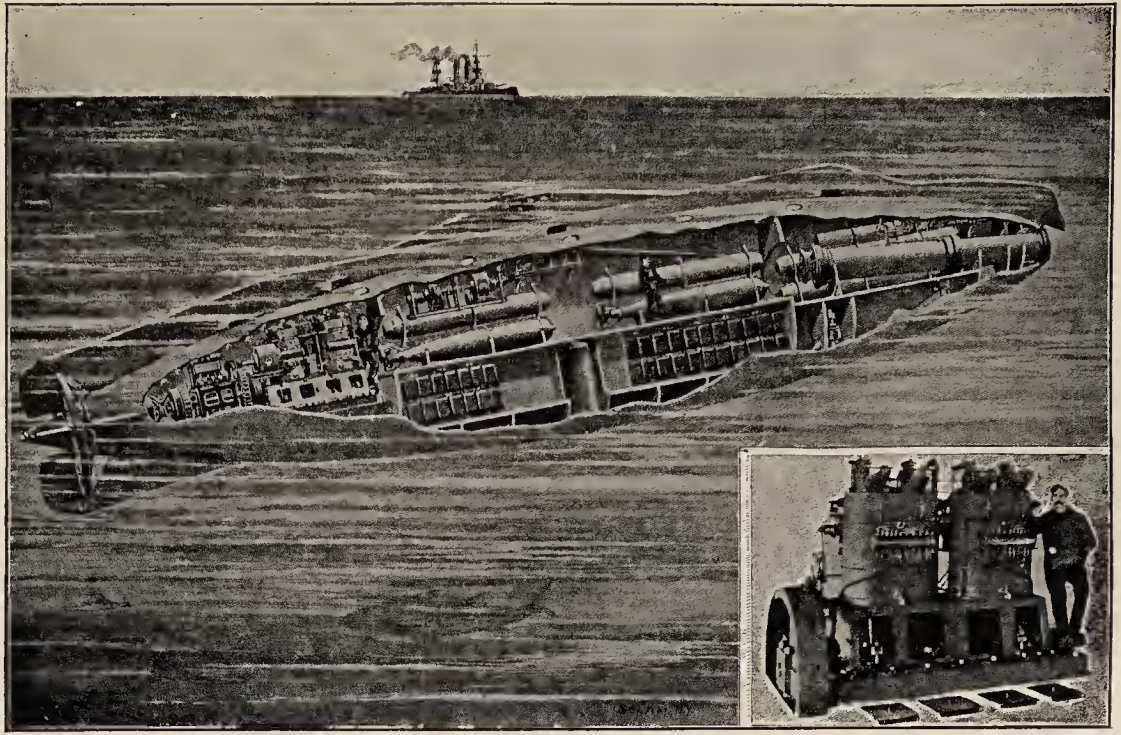
Petroleum Motor Coach on an English Railway.

nately to all engines which derive their power from the " explosion " of gas or oil spray when mixed with air in a cylinder. This explosion is nothing more than the very rapid burning of the fuel which may be artificial or natural gas, gasoline, naphtha, benzine, or even kerosene, but its sharp report is a familiar sound in every corner of the world. Here only those engines using petroleum products need be considered; to this class the name gasoline engine is generally applied from the fact that commercial gasoline is the chief oil used. Differ-

ent types of engines use the oil in the form of spray, as a vapor compressed with air, or by converting it into gas, but the underlying principle is essentially the same. In every case the power is generated by the high degree of heat created, and consequent great expansive force developed, as the mixture of oil and air is fired in the combustion cylinder. This expansive force works exactly like steam in a steam engine, in driving the piston back and forth, the power thus developed being transmitted by rods and a crank shaft as in other engines.

Engines depending on this principle of the expansive force of air and fuel undergoing combustion in a cylinder were suggested before the days of steam power, yet the actual importance of this type dates from the perfection of the Otto Gas Engine, only about forty years ago. The last fifteen or twenty years, in fact, have marked the major part of the enormous increase in the employment of engines using gasoline, partly as a result of the greater ease in securing regular supplies of the oil, but mainly through the application of gasoline engines to automobiles and small boats. These uses suggested the great possibilities which were capable of development, and, as a result, many different engines, varying only in minor details, have been put on the market.

The early engines were not regarded as suitable for plants requiring more than fifty or sixty horse power, but at the present time the multiple cylinder



Submarine Torpedo Boat with its Marine Gasoline Engine.

types are built to develop hundreds of horse power. Big industrial establishments now find gasoline engines economical in many ways, the advantages being no less marked than in the case of petroleum fuel for locomotives and steamers. Gasoline engines have invaded almost every trade and every country in the world. The modern system of distributing oil affords, even in the small country town, a ready means of securing the necessary fuel, and, on all sides, from the modern factory down to the rough mill in the backwoods, from the needs of the great manufacturer to those of the modest farmer, the gasoline engine has proved its usefulness. In the old days the sawmill or gristmill had to wait for the water to turn its wheel, now power is always ready at a minute's notice. Old-fashioned wood sawing and churning laboriously by hand have given way to a small "motor," which performs both services equally well, besides supplying power for pumping water, threshing and grinding grain, turning a lathe or grindstone, and any other need that may rise. So it is all through the modern industrial world, with thousands of engines, especially the small ones of a few horse power, performing a service which cannot be overestimated. The small steam engine and boiler has almost entirely disappeared and in its place the gasoline engine does the same work more conveniently, more cheaply, and more satisfactorily.

The marine gasoline engine has just as completely revolutionized the character of small craft.

No one who has watched the enormous growth of the fleets of "power boats" for pleasure purposes can doubt the value of the gasoline engine. To the thousands of fishermen using small boats in the shore fisheries up and down our coast, it has come as a wonderful boon. These men who were so sorely vexed by wind and tide ten years ago, now calmly make their way to and from the fishing grounds irrespective of the weather. Head winds no longer cause troublesome delays; to get becalmed on the way to market with a valuable catch is no longer feared. The small engine now carries the fishermen out and brings him back at his will independent of the fickle breeze. By scores and by hundreds the fishermen everywhere have adopted this auxiliary power, which has opened a new era for them. Larger sailing vessels, too, especially in the coastwise trade, are installing gasoline engines, even up to several hundred horse power, for the advantage of auxiliary power is very great when entering port, or when the wind is light. The time is probably not far distant when the major portion of the big coastwise fleet will be so equipped.

Yet most significant of all perhaps is the place occupied by the gasoline engine in the development of submarine torpedo boats to which so much attention is now being given. The economies of space offered by this type of engine and its fuel supplies, and especially the much less intense heat emanating from the engine, are the real factors on which submarine craft depend for their success.

The lubricating oils, from the standpoint of present-day mechanical processes, fill a need which is hardly less important than the need for artificial light or for fuel. No other lubricating oils in the world can rival those obtained from the best grades of paraffin petroleum from the Appalachian fields. Their reputation extends to every part of the world, and nine tenths of the world's machinery at the present time uses petroleum lubricants. These oils are superior in every way to the old animal or vegetable lubricants, safer, cheaper, more likely to be pure, and do not gum so readily. It is not surprising, therefore, that millions of dollars worth in sum total is being exported annually with consignments going to every country where modern machinery is used.

An innumerable number of special brands or grades of straight petroleum lubricants are made for different purposes and sold under trade names. At the same time, a constantly increasing number of compound oils, mixtures of petroleum oil with some vegetable or animal oil, are coming to be preferred for certain uses. Other oils or greases are commonly made by grinding graphite, mica, or some insoluble soap with a petroleum lubricator, for use in heavy, slow-moving machinery.

Every conceivable grade of oil, from the very thinnest and lightest down to the heaviest axle grease, finds a place in the list of petroleum lubricants, while the single use of certain grades in steam cylinders makes their manufacture indis-

pensable. High-pressure steam decomposes animal oils and causes the formation of fatty acids which act on all common metals thus injuring the engine. Pure petroleum oils, however, are unaffected by high-pressure steam and consequently fill an extremely important place in all big power plants.

A much used form of lubricating oil, though not

"Motor" Plow Using Gasoline Engine.

usually regarded as such, is the familiar compound known as vaseline. Vaseline is solely a trade name for a product of petroleum originally introduced by the Chesebrough Manufacturing Company, of New York. In its character it is more closely related to the lubricating oils than any other of the products. The Chesebrough Company, now a part of the Standard organization, controls the name,

vaseline, through its patent rights, but other concerns are manufacturing essentially the same thing under such names as—petrolatum, petrolene, petroleum jelly, cosmolene, and so on. Vaseline finds its principal use in the drug industry where it fills a long-felt want. It can be mixed with most drugs without any chemical action taking place, thereby making it possible to compound salves and similar remedies, mainly for external use, which will keep unaltered for a long time. This use of vaseline is now the only important medicinal application of any petroleum product.

Paraffin first became important in the manufacture of paraffin or wax candles, in which it has almost completely displaced the sperm candle and tallow "dip." Persistent efforts in booming its use and placing it on the market in convenient form have succeeded, however, in making paraffin an indispensable article in a variety of manufacturing processes as well as in ordinary household use. The enumeration of a few of these will illustrate its value. In the manufacture of matches, it is used as a coating for the heads to make them waterproof, and it finds a similar use in waterproofing fabrics. It is used as a lining for barrels; in glazing paper; and in the manufacture of "wax" or "oil" paper; in the manufacture of ornaments from gypsum and other minerals; in laundry work; as a preservative for foods of all sorts, especially in the domestic canning of fruits; in waxing flowers; to protect labels and stoppers in bottles of corro-

sive liquids; in electrical work as an insulator; as the basis of chewing gum; and for a host of other uses of every description.

Besides these uses of the principal products already enumerated, there are a multitude of other ways in which petroleum compounds are employed. The lighter products are used as solvents for caoutchouc, various fatty oils, and especially to dissolve resin in the manufacture of varnish. They are used as substitutes for turpentine in mixing the cheaper grades of paints, in extracting oils from seeds, in the manufacture of linoleums or oilcloths, in extracting greases from leather, in the preparation of jute, in dry cleansing, and so on. The crude oil is used to kill insects, as in the successful campaign against mosquitoes in many malarial districts or against the San José scale on fruit trees. It is used to protect animals against certain pests, as the gadfly, and to cure various skin diseases. It preserves piles and wharf timbers from the injurious action of water and the many destructive forms of animal and plant life, being just as effective as the more expensive creosoting. It is used very widely and successfully on railways and on macadam carriage roads to prevent the dust nuisance, being much more lasting and far more efficient than water. From the tar valuable dyes are made and even the coke from the tar still is ground and made into electric-light carbons, artists' crayons, and the like.

The whole realm of common uses for petroleum

produets is almost beyond coneeption. Some faint idea of the tremendous importance of the petroleum industry in its relation to other industries may be gained from the simple statement that, save for the water he drinks and the air he breaths, every possible necessity of a man's life may be supplied either directly or indireetly through the use of petroleum products; even his supply of water may be pumped by a gasoline engine.

CHAPTER IX

THE REMARKABLE GROWTH OF THE OIL INDUSTRY IN THE UNITED STATES

The marvelous expansion of the petroleum business in this country is without a parallel in the whole realm of industrial and commercial development. It is a magnificent tribute to the success of American energy and ingenuity, in spite of the bitter criticism directed against it and the general deliberate ignoring of its real importance. Periodic eruptions of worthless stock companies, swindling a class which is ever ready to be duped again, and the fact that a single small group of men has come to control nine tenths of the industry, have been deemed sufficient reason for hurling invectives at the very mention of oil. But, whatever the moral or legal virtues of these cases may be, they do not in any way detract from the value of a product which stands so high on the list of our national resources.

Within the space of a single lifetime, easily within the memory of the older generation to-day, the petroleum industry has grown from nothing to gigantic size. Fifty years ago a group of men in

New Haven were planning to send a railroad conductor to seek for oil. Now over 50,000 wells are turning out millions of barrels of oil a year. From the narrow confines of Oil Creek Valley, in Pennsylvania, the industry has spread ever outward until it touches the four limits of the country, from Pennsylvania to California and from Texas to Alaska. A half dozen great fields, widely separated and of different characters, support active operations in more than a dozen states. What was a local experiment in a few backwoods counties has grown to be a great industry of the whole nation.

In 1859 the entire output of petroleum was only 2,000 barrels; now over two hundred times that quantity is produced every day in the year—over 160,000,000 barrels in a twelvemonth. From the time Drake's well began to yield, in 1859, until the close of 1907, the total production for the forty-eight years reached the stupendous figure of 1,800,000,000 barrels. Such a quantity is so inconceivable that it means nothing except through comparison. Allowing five and six tenths cubic feet for the average barrel of forty-two gallons, this quantity would fill a lake covering some hundred square miles and five feet deep. If stored in the ordinary 40,000-barrel cheesebox tanks, the tanks would make a solid line for over 700 miles. With the whole quantity placed in the average-sized barrels lying end to end, the line would cover over 750,000 miles or much more than sufficient to form a con-

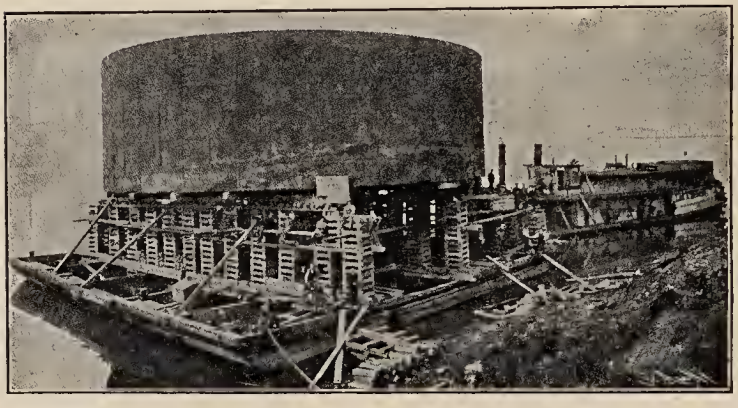
tinuous loop passing ten times around the earth at the equator, to the moon and back again.

Oil which had practieally no general use half a century ago, even at home, now occupies an essential part in a host of industrial proeesses and finds its way into practieally every civilized quarter of the globe. In the home use alone it has added enormously to the wealth of the country, but it has not stopped there. Billions of dollars have been netted from its sale in foreign countries. In recent years it has brought from other nations of the world a return of $10,000 an hour for every hour in the day and every day in the year. Sueh unparalleled commereial development in so short a time is truly entitled to stand as one of the greatest of all the great events in the closing years of the nineteenth century. Yet the praises of oil are rarely sounded.

Like most other mineral industries, the expansion of the petroleum business during the half century of its existence has been in a series of great leaps and bounds as new produetive areas have been successively discovered and developed. Sudden booms in new districts and rich strikes in old fields have marked the whole progress of oil history, so that where one year saw a production of only a few thousand barrels, the suceeeding year might witness a production risen to millions of barrels in one sudden leap.

Everywhere the increase a hundred- or a thousandfold in a few years has been a typical feature of the development as eaeh field has entered on its

period of important expansion. In the eighties it was Ohio; in the nineties, West Virgina and California; and in the last decade, it has been Texas, Kansas, and Illinois. The production of fifty barrels in Texas in 1895 had risen to over 28,000,000 ten years later; and an industry yielding 200 barrels in Illinois in 1902 has grown to a 24,000,000-barrel industry in five years. Such prodigious



Moving Oil Tank to a New Field in Pennsylvania.

additions have sufficed to make the total production of the country rise rapidly and with only occasional, brief downward turns. But success has been won and maintained only by the unfailing adherence to the oilman's creed—drill, drill unceasingly in new fields and old.

The early development of the industry must be credited bodily to western Pennsylvania. For fifteen years after Drake's well began to yield an "incredible quantity, at the rate of twenty-five

barrels a day,'' Pennsylvania produced practically the entire yield of crude oil. The extension of operations in all directions from Oil Creek had brought the total amount above 10,000,000 barrels by 1874, yet only small additional supplies were produced outside the limits of that state.

During the boom days in the sixties, the hope of '' striking oil '' led to the drilling of wells everywhere from Michigan to Alabama, and from Massachusetts to Missouri. Traces of oil, it is true, were found in innumerable cases, but, with a few exceptions, they were nothing more than traces with absolutely no prospect of securing oil in paying quantities. The two important exceptions were in West Virginia and Ohio. After Drake's success, boring for oil was done in both states, and several producing wells were struck. In West Virginia, a second oil boom to rival the one in Pennsylvania was beginning, with a town projected and a crowd of speculators at hand, when the Civil War broke out. Confederate raiders burned the stores of oil, destroyed the wells, and completely obliterated all trace of the progress made. Successful operations were resumed in 1865, but the combined supply from both states ten years later was less than two per cent of the total production for the country.

The first important development outside of Pennsylvania came in 1885 and 1886 in the northwestern part of Ohio, in the district since known as the Lima field. The development started more or less accidentally through efforts to secure a sup-

ply of natural gas. This product of the oil regions was then being very profitably used in Pennsylvania, and for many years it had been burned on a small scale in the vicinity of Lima, Ohio. In 1885 a well drilled in an attempt to secure a larger supply of gas near that place produced a fair quantity of oil instead. This result was entirely unexpected, for all the Ohio petroleum prior to that time had been confined to a small district in the southeastern part of the state along the edge of the great Appalachian field.

The new deposit was wholly unlike that found in the older localities, the character and quality being quite inferior to the Pennsylvania product. In fact, the color was so dark and the odor so disagreeable that the oil was regarded with general disfavor. It was the first of the sulphur or "stinking oils," and because this quality prevented its manufacture into kerosene by the processes then known, its use was confined largely to fuel purposes for some time. But, strangely enough, the character of the oil had no bad effect on the rapid expansion of operations. There was a plentiful demand for fuel, and as wells were drilled in great numbers, the production for the state increased with giant strides.

Ninety thousand barrels in 1884, then over half a million, a million and three quarters, five million, ten millions barrels, is the summary of four years' growth. By this time persistent experiments had succeeded in perfecting processes to eliminate the

sulphur and make possible the manufacture of kerosene from the Lima oil. Ohio refined products immediately became an important factor in the oil market, and at the same time the oil was more valuable to the producers. Additional developments were thereby directly stimulated with the annual production steadily mounting upward. The eventual outcome was already apparent, for the older localities were slowly dropping back from their long unrivalled position so far in the lead. In just ten years from the time the Lima field was opened, Ohio forged to the front as the most important petroleum-producing state in the country. For full thirty-five years supremacy, undisputed, unapproached, in the country, in the whole world even, had belonged to Pennsylvania, the pioneer. Now the leadership was gone from the states of the Appalachian field, never to return.

West Virginia was the next one to enter the ranks of important producers. A wildcat well drilled in the fall of 1889, in Marion county, far away from any other known productive area, proved to be a profitable venture, and, in spite of the necessity of drilling to great depths in most localities before the oil-bearing strata were reached, the industry increased immediately. The Pennsylvania output was declining rapidly during the nineties, nothwithstanding every effort to keep it up to former levels, and at the end of the decade it was forced to yield second rank to the younger field to the south.

The operations in Ohio spread across the State line into Indiana early in the nineties, and that portion of the Lima-Indiana field was the scene of vigorous drilling. These important strikes in the new Ohio and West Virginia fields also led to renewed, persistent efforts to discover oil in a great many places where some indications of its presence were known, but where previous attempts had not been particularly encouraging in their results. A number of new districts were thereby proved to be oil bearing. Kentucky and Tennessee, containing the southern extremity of the great Appalachian field, developed a few successful wells and appeared in the list of productive states, though they never attained any importance. Illinois, Kansas, Texas, Missouri, Indian Territory, and Wyoming all yielded a few barrels of petroleum each year from about 1890 onward, while California and Colorado gave many indications of becoming important producers.

The Colorado region in the vicinity of Florence, between Pueblo and the famous Royal Gorge, was the scene of prospecting operations as early as 1862, during the general attempt to find oil throughout the country. Small supplies were found near the surface and the usual stock companies were formed, but the total output, instead of increasing as it gave good promise of doing at one time, has steadily declined for the last fifteen years.

California, however, has borne out every possible expectation so far as the quantity of oil is con-

cerned. The existenee of oil in California was known from the very beginning of its settlement. Oil floating on the surfaee of the oeean off the shores of Santa Barbara county was a constant souree of wonder among the early navigators, and a semi-solid form of bitumen, formed apparently by the slow seepage of petroleum, was widely used as fuel and as a sort of eement roofing for houses.

This general knowledge of the existence of important petroleum deposits somewhere underground led to the usual course of events at the time of the Pennsylvania boom. Professor Silliman, of Yale, whose favorable report had furnished the basis for Drake's operations, was secured to make a report on the oil from seepages in Ventura eounty, California. His report here, also, was glowing with praise for the new oil and its possibilities. Coming just as it did, near the height of the Pithole excitement, it aroused wild enthusiasm among the speeulators. Developments were started from one end of the State to the other, and in their dreams promoters saw California turned into one great oil field. But trouble quickly appeared; drilling was extremely diffieult, slow, and expensive. It soon leaked out that the samples of oil tested by Professor Silliman were quite unlike the low-grade oils found in the wells. None of the loealities outside of Ventura county could be profitably operated. The boom was short lived.

More than a quarter of a century later, a well was drilled near the old asphalt deposits in Los

Angeles, and a small steady supply of oil was secured. Once more the whole State was drilled over amid feverish excitement, and once more without success for some time. The Los Angeles wells, however, were visible proof that the oil was not confined to Ventura county. This knowledge was highly comforting and encouraging to the prospectors who had been filling the State full of holes, and wildcat drilling went on with untiring energy. In 1895 and 1896 the much-deserved success finally crowned their persistent efforts. The climax came when the famous "Blue Goose" flowing well was struck in the Coalinga district only to be followed immediately by the more important strikes at Bakersfield.

The boom of thirty years before was repeated on a much grander scale. Between two and three thousand oil companies were chartered in the course of three years; all of them sold stock, most of it in the East, and probably half of them really sunk wells in some part of the State. Large sums of money were undoubtedly lost by the public through mismanagement and dishonesty on the part of officials and promoters, but the benefit to California was undeniable. New territory was proved productive by wells sunk where sane interests would probably never have risked a penny, and by the time the excitement had subsided, the production was approaching 8,000,000 barrels a year, from which point it has risen steadily to nearly 40,000,000 barrels in 1907.

One direct result of the oil craze is to be seen in the curious spectacle of oil being pumped from beneath the sea, at Summerland, a condition to be found nowhere else in the world. No less than several hundred productive wells have been drilled from derricks erected on piers which extend a thousand feet out into the surf, some of the wells having yielded profitably for a number of years.

The successful expansion of operations in California was followed, and for a time quite outdistanced by the developments accompanying the great Texas boom. The story of the Texas fields is much the same as in California. Oil was discovered there as early as the sixties, though no valuable supplies were encountered until about 1894. Then a well drilled for water near Corsicana struck a good flow of oil at a depth of somewhat over 1,000 feet, but curiously enough no attempt was made to secure the oil at that time. The news that oil had been encountered, however, was spread, and a few years later outside interests began what proved to be the first successful oil development in Texas.

A great rush began immediately; operators and speculators flocking in from the older fields of the east, converted the little town of Corsicana into a noisy, hustling city. Derricks sprang up by scores; wells were drilled within a few feet of one another, and yards, gardens, house lots, every available foot of surface was soon occupied. The production of crude oil in the State rose from fifty barrels in 1895

to over 800,000 barrels in 1900, but these results fell far below the original expectations. The excitement, therefore, subsided almost as rapidly as it had appeared, only to be repeated tenfold a few years later.

The great Texas strike of 1901 is still fresh in the memories of many. For years the escape of gas from the earth about a low mound near Beaumont, known locally as Spindle Top, had been regarded as indicating the presence of petroleum. In fact, a town had been laid out in 1894 and a well some 400 feet deep had been drilled there without finding oil. Nothing more of importance happened until a new well drilled in January, 1901, suddenly burst forth as a giant gusher, sending a solid stream of oil high above the derrick and yielding at the rate of 70,000 barrels a day. Such production had never before been heard of in this country. The news of the great Beaumont spouter brought consternation to the hearts of oilmen in every important field. They could hardly realize the magnitude of a well capable of producing nearly half as much as the previous yield for the whole country. Only three such wells would more than double the former production! Small wonder it is that the news of the inferior quality of the oil was hailed with delight by oilmen all over the world.

But the quality of the oil did not in any way lessen the mad rush to secure territory in the vicinity, any more than it had in Ohio fifteen

years before. Land sold at the rate of $100,000 an acre, and many experienced operators, failing to secure plots on any favorable terms, deserted the field entirely. Their places, however, were more than filled by the swarm of speculators and promoters who would agree to any terms, no matter how exorbitant, in order to get a lease. An enormous crop of stock companies was started immediately, and for a few months investments and actual drilling operations were made in an absurdly reckless manner. The belief that the oil territory extended for many miles in every direction was speedily and effectively shattered. Numerous other gushers, some approaching 100,000 barrels a day at first, were struck, it is true, but it soon became clear that the productive area was wholly confined to about 300 acres covered by the Spindle Top mound. Outside of those narrow limits drilling was of no avail. Nowhere since the days of Pithole City had there been such a wild rage of oil excitement. Never before had so much utterly worthless stock been unloaded on a guileless public, despite the bitter lessons of half a dozen previous bubbles. No other collapse was quite so sudden and complete.

The Beaumont gusher, however, was the forerunner of developments which temporarily placed Texas among the leading oil-producing districts in the world. Spindle Top alone yielded to the few lucky ones over 30,000,000 barrels in the first four years of its meteoric career, while other pools

quickly appeared with yields more than sufficient to counteract its failing supply. Sour Lake, Batson, Saratoga, Humble, all repeated on a smaller scale the history of Spindle Top, with gusher after gusher helping to swell the total for the State until, in 1905, it reached its climax with over 28,000,000 barrels.

This unprecedented rise of California and Texas greatly changed the aspect of the industry. Up to 1901, the Appalachian and the Lima-Indiana fields had been the main source of supply. In spite of the gradual decline in all the older areas, these two fields were still yielding more than three fourths of the total for the country, which had never risen much above 60,000,000 barrels a year. Practically all of it was high-grade oil for both illuminating and lubricating purposes. Beginning with 1901, however, the enormous supplies of the lower-grade fuel oil from California and Texas pushed the total production steadily upward, more than doubling the output in five years.

Indiana was the next scene of great excitement over gushers struck in deep sand in 1904. Fabulous prices were paid for land, dividends of fifty per cent a month were declared, and the state rose with a single bound to an important position in the production of high-grade oil. Kansas followed the same example with extensive operations begun in 1903 and extending into the following years, when scores of wells were often completed daily. The productive territory was proved to extend

over several thousand square miles in Kansas and what was then Indian Territory—the largest productive area in the United States, and perhaps in the world. Two years later the yield from this district ranked second only to the California fields, and in 1907 it broke every existing record with an output of over 45,000,000 barrels, or more than the whole country ever produced in a single year until 1890. This enormous yield was entirely beyond all expectations, and it became a serious problem to take care of the oil, a difficulty that was solved only by the erection of hundreds of storage tanks to hold the surplus stock.

The oil fever in southeastern Texas spread across the State line into Louisiana, where surface conditions closely similar to those at Spindle Top were known to exist. The first great gusher of the Jennings field was opened in 1904, its success resulting in other wells being sunk rapidly. One well produced over 1,500,000 barrels in the first five months of its existence, and others of the same sort suggested a repetition of the meteoric career of Texas. Illinois sprang from obscurity into sudden prominence in 1906, when several thousand wells drilled in the eastern part of the State met with almost universal success. The production increased immediately from almost nothing to between 4,000,000 and 5,000,000 barrels in that year and over 24,000,000 barrels a year later, the most rapid development that any area has ever shown. Strangely enough this enormous development was accom-

plished in a thoroughly businesslike manner, with none of the usual excessive land values, little speculation by mere adventurers and no stock peddling companies.

It was fortunate that these new fields appeared as they did, since the decline of the Texas yield in 1906 more than offset the new developments. For the first time in a dozen years, the total production of the country showed a marked drop, falling from over 134,000,000 barrels to about 126,500,000 barrels. The great developments in Kansas and Illinois, with the steady growth in California in 1907, however, carried the total yield to a figure never approached before, over 166,000,000 barrels, or nearly twice as much as all the rest of the world produces.

One of the most astonishing features connected with this steady expansion of the industry into new areas has been the great change in values. Excessive prices have, of course, been paid for oil leases in practically every field down to the present time, but, as a whole, the later years have been marked by more and more rational conditions. The total investments at Pithole, for example, exceeded $25,000,000 during the short period of its existence, whereas the Washington field, twenty-five years later, represented an investment of less than $2,000,000, and produced many times the amount of oil yielded at Pithole. More oil property changed hands in a day during the early booms than was transferred in a whole year two

or three decades later, and every transaction meant a revaluation above the former figure. Still later, the development of the Illinois field, in reality a greater boom than was ever seen in the Appalachian field, has marked an almost complete elimination of the reckless speculative element. There bonuses of a few hundreds, instead of thousands, of dollars were paid on leases and royalties of an eighth of the oil instead of one third or one half, were accepted.

Such is the story of the petroleum industry of the United States, where it has attained a magnitude far above that of its closest rival. From a venture regarded with general skepticism, an industry involving millions of dollars and employing 100,000 persons has sprung up and expanded until it covers every section of the country. With great leaps and bounds, as field after field has been brought in, expansion has continued until it seems as if the limit must have been nearly reached.

The original small refineries have been replaced by enormous plants each capable of handling thousands of barrels daily. Van Syckle's modest pipe line has grown into a network of feeding and trunk lines, sufficient to girdle the earth three or four times. Drake's well has to-day more than 50,000 descendants in actual operation, and an unnumbered host of others which have proved to be failures or have ceased to yield. Petroleum products unheard of fifty years ago, have long since been

manufactured by millions of tons yearly to fill a multitude of demands in everyday life. On all sides expansion has been on a scale truly marvelous in its proportions, and greater, far greater than ever before, during the last ten years.

CHAPTER X

THE GREATEST CORPORATION IN THE WORLD

The idea of monopoly has, of late years, come to be inseparably associated with the petroleum industry in this country as a result of the tremendous operations carried on by the Standard Oil Company. But oil monopolies are apparently as old as the industry itself. During the Persian days of possession in the Apsheron Peninsula, the Khan of Baku controlled the entire output of the oil springs, reserving the revenues for his personal use. This monopoly was continued, in one form or another, by the Russian Government until 1872, because the industry was profitable and the revenue was good.

A more interesting and probably much more ancient monoply than the one at Baku is said to have existed in Burma for unknown ages. There the privilege of digging for oil in the Yenangyoung field, in the Irrawaddy valley, was a hereditary right possessed by twenty-four families and handed down like a title of nobility from father to son for generations. The monopoly was perfect; no outsider could become a well owner even by purchase;

the owner must be a member of one of the *Yoya,* or hereditary families. The head of each family alone had the power to grant permission to dig; he indicated the site for the well; and he received a royalty on the amount of oil secured. Only in cases of no direct descendants to inherit the right could the privilege be sold, with the consent of all the other joint holders, and then solely to some distant member of the same family.

Modern times present no parallel to this close corporation, but the tendency toward powerful concerns and the elimination of small enterprises has been evident everywhere that the industry has risen to important proportions. In a way, the very nature of the industry demands a certain amount of centralization of interests for its own protection. No other industry offers greater opportunity for self-destruction through cutthroat competition and consequent lowering of standards. Concentration of control, or a combination of interests to some extent, is the only means of protection against the constant recurrence of such conditions. Nowhere else has this natural concentration gone so far as in the United States, where it has resulted in the development of the greatest corporation in the world. Nowhere else has the industry reached such a high degree of efficiency and perfection as it has under the guidance of this corporation. Baku, Burma, the Dutch Indies, and Japan, it is true, have powerful corporations backed by large capitals, but none of them can

stand as a peer of the Standard Oil Company. Standard Oil has come to be a familiar name from one end of the world to the other, from the islands of the ocean to the wildest parts of the African desert, from the heights of the Andes to the barren wastes of Chinese Turkestan; because it has stood

A Standard Oil Tank Wagon in India.

firmly for high quality of products and has perfected the organization necessary for seeking markets wherever human endeavor can transport a case of kerosene.

Technically, this mighty combination is the Standard Oil Company of New Jersey, a corporation with a capital of $100,000,000, chartered simply to hold the stock of a whole series of sub-

sidiary companies, but endowed in its "omnibus" charter with the right to engage in almost every conceivable line of industrial activity. Practically, the Standard Oil Company, as the dominant power in the petroleum business, is a multitude of different interests, brought under the control of a small group of men. Oil wells, refineries, pipe lines, distributing and selling companies, and manufacturing concerns of a dozen different sorts, in half the states of the United States and in every important foreign country make up the framework of this all-comprehensive organization.

This greatest of all petroleum concerns is without any kind of serious rival in this country. The various affiliated companies comprising the Standard interests handle over eighty per cent of the crude oil put through the refining process; they produce over eighty per cent. of the refined products, gasoline, kerosene, and lubricating oils; and they control about the same proportion of the foreign trade. Standard pipe lines transport nearly all the crude oil in the eastern and mid-continent fields, as well as increasing quantities in Texas and California. In large sections of the country Standard products have absolutely no competitor in the market.

Outside of the Standard organization, there are only about seventy-five refineries, most of them small, whose total annual consumption of crude oil is considerably less than that of the two Standard plants at Bayonne, New Jersey, and Philadelphia.

Nearly a score of these so-called independent operators are independent only in name. They are, in fact, so absolutely dependant on Standard pipe lines for their supply of crude oil that if the Standard so desires, they can be rendered quite incapable of presenting any effective competition. Actual competition of any kind, therefore is possible only on the part of some fifty-odd small concerns scattered about the country and representing perhaps as much as a sixth of the whole industry.

The first step toward concentration was largely a natural outcome of the character of the industry itself, especially as it existed under the unstable conditions prevailing from 1860 to 1870. The opening of Drake's well had marked the doom of the coal and shale oil industry and forced the manufacturers to change their plants over to petroleum refining. For a time these converted plants and the new establishments started in the oil regions were fully capable of handling all the oil produced. But the oil developments ushered in by the first deep wells yielded greater quantities than had ever been dreamed of before. This unexpected supply and the rapidly increasing demand in all quarters for the refined products soon overtaxed the powers of the existing refineries. Small concerns were the prevalent type at that time, and their limited resources rendered them incapable of adopting the improvements needed to meet the new demands of the industry. Large amounts of

capital were necessary to erect and operate plants of great capacity; to improve and cheapen the existing processes of refining, and to profit from various economies in handling, such as the building of spur tracks from refineries to the railroads, construction of pipe lines or control of tank-car service. Such advantages could be secured only by some powerful single concern or through the combination of several smaller interests.

A small group of refiners in Cleveland, Ohio, were among the first to recognize this condition of the industry and to see the latent possibilities afforded by a combination of interests. The inception of the idea is usually credited to John D. Rockefeller, who had begun oil refining in 1865, and has long been the most prominent figure in the oil industry of the world. The first move toward combination was made about 1867, when the firm of "Rockefeller, Andrews and Flagler" took over the group of refineries in which Rockefeller, his brother William, Henry M. Flagler, Samuel Andrews and Stephen Harkness were interested. All these refineries were located in Cleveland, Ohio, where a score of other concerns were operating independently, the object of the Rockefeller combination being mainly to do a larger business than their local rivals by uniting their efforts. At first the firm merely expanded its own business, without attempting to absorb others or engaging at all in the production or transportation of oil. By sticking to this policy the new firm forged ahead so

steadily that within two years it was by far the strongest concern in its locality.

The time was now ripe for the next move toward expansion. It came in 1870, when the partnership was changed to a corporation with $1,000,000 capital, under the name of the "Standard Oil Company of Ohio." This was the first appearance of the name which has since become familiar in every household in the country. It is estimated that there were then fully 250 refineries scattered through the states from Ohio to the coast, with a total capacity of about 16,000 barrels a day. The Standard works at the time of incorporation were capable of handling about 600 barrels daily, thus making them one of the most important individual establishments, but probably not much larger than some of their chief rivals. The reorganization, however, was epoch making; it marked the beginning of the active campaign of expansion and for control of the industry, which has continued unabated down to the present time.

The campaign was conducted along two main lines: first, to absorb other refining interests and secure control of that end of the business; and second, to obtain advantages of shipment not enjoyed by rival operators, as a means of eliminating existing competition and of crushing rivals which might appear in the future. Both of these struggles were carried on relentlessly and more or less simultaneously during the succeeding decade.

The first effort at expansion was directed toward

the independent refineries situated in or about Cleveland, and, in the course of two years, practically all of them, to the number of a score or more, had been secured in one way or another. Having thus established themselves securely in their own region, the Standard operators were in a position to turn their attention toward certain outside localities. Plants were first acquired at New York, Philadelphia and Baltimore to afford a foothold in both seacoast markets and in foreign trade, where the consumption was increasing enormously each year. The attack was then directed to the independent refiners scattered through the Pennsylvania oil regions and in three years the majority of them had been forced to surrender.

This policy followed everywhere, soon yielded to the Standard practically absolute control of the refining business. In 1870 the newly formed Standard corporation had represented not over five per cent of the total refining business. In 1878 the principal competitors had been so thoroughly eliminated that the Standard controlled about ninety five per cent of the business. Thus the first object, the domination of the refining business, had been successfully attained.

Various means had helped carry the process of absorption to such a satisfactory result. The larger concern had been able to adopt the many desirable innovations which small capital could not afford. Distinct advances in the methods of refining, perfected by long and costly experiments, made it

possible to distill grades of oil previously of little value, to utilize products hitherto lost in the residuum, and to make better products at less cost. Other economies were introduced by the Standard in the manufacture of their own barrels, cans for case oil, boxes, paint, glue, acid, and so on, all helping to lessen the cost of putting the refined oils on the market, in ways which were entirely beyond the reach of the small plant. Acquisition by direct purchase or by consolidation, forcing their rivals to the wall by underselling and various other methods, were adopted to suit individual cases. The financial depression of 1873 also found the Standard well prepared to survive it, while many smaller concerns were quickly reduced to a condition where absorption by the trust was inevitable. But the most important factor of all was undoubtedly found in the rebates and discriminations in freight rates which the Standard was able to secure from the railroads.

Cleveland was plainly a strategic point, as compared with Pittsburg or the oil regions, for the purpose of securing favorable rates on oil shipments. It was the happy possessor of two routes to the eastern markets and the seaboard: it had the New York Central Railroad and the water route by way of Lake Erie and the Erie Canal. At any time the refiners could easily ship by water if the railroad refused to give them satisfactory terms. The oil traffic was so important that the railroad, then struggling for existence, could not afford to

let it go elsewhere and the Standard knew it. The result was obvious. This fact of competing rail and water transportation made it possible for the Standard to demand greater and greater concessions from the railroad, and the latter, utterly helpless, was forced to yield. Such a condition, of course, became a tremendously powerful weapon in the campaign against competitors and greatly facilitated the process of absorption. The enjoyment of freight rates a third or a half less than those paid by other operators made the Standard irresistible whenever it chose to crush independent interests and absorb them at its own price.

Why this particular group of refiners always secured the greatest concessions has always been a mystery. All the railroads at that time made a general practice of favoring large shippers to build up freight traffic, but how the Standard ever managed to wield such enormous power over the railroads is unexplainable. It extended in some cases even to demanding and securing rebates on all shipments made by their competitors, or literally compelling the railroad to pay the Standard for the privilege of carrying some one else's oil.

As soon as it had acquired a firm hold of the refining branch of the business, the Standard turned its attention to the control of the pipe lines, which connected the wells with the local refineries and main shipping points on the railroads. When this third progressive step of expansion was begun, about 1874, there were many miles of pipes in the

oil regions, operated by a large number of competing companies, but few lines exceeded ten miles in length. The United Pipe Line Company, the first controlled by the Standard, was formed in 1874, and immediately entered into an agreement with the other leading pipe companies concerning a schedule of rates and special rebates to be received from the railroads. The companies participating in the agreement were consolidated into three main concerns: the United, the Columbia Conduit and the Empire Transportation Company, the United also having acquired by purchase most of the lines which had not been asked to become a party to the agreement.

Lack of harmony, however, quickly disrupted the alliance and precipitated a brief but fierce war for supremacy between the three transportation companies and their associated refiners. The pipe lines were still merely serving as feeders to the railroads, so that the latter were also unavoidably drawn into the conflict to protect their own valuable interests. Each one of the three main pipeline companies, therefore, allied itself to the railroad system with which it was most intimately associated in handling oil shipments: the Columbia Conduit Company with the Baltimore & Ohio; the Empire Transportation Company with the Pennsylvania; and the United Pipe Line Company with the Erie and the New York Central.

After a short period of armed peace following the disruption of the pipe-line alliance, the Empire

Company precipitated hostilities by securing possession of a refinery on New York harbor, and beginning the erection of another at Philadelphia. Both Standard interests and those of its railroad allies were threatened by this encroachment on their most highly prized preserves, and a furious struggle immediately began between the Standard and the New York Central on the one side, and the Empire and the Pennsylvania Railroad on the other. For six months the latter exerted every means in its power to crush the United Pipe Line and the Standard Oil Company. The Pennsylvania Railroad carried oil at a rate far below the actual cost of hauling, while the independent refiners connected with the Empire Company sold oil for almost nothing in the territory previously controlled by the Standard. It was a case of attacking the Standard with its own weapons. But concentration of power had gone too far; the Standard position was already rendered impregnable by its unlimited resources, and the Empire Company, unable to continue the conflict longer, was forced to yield in 1877.

The victory over the Empire Company gave the Standard a new advantage, which was speedily improved. The Columbia Conduit Company was easily absorbed, while a score or more of smaller companies, in fact, all which threatened to become competitors, were acquired by purchase.

Thus, within eight years from its incorporation, the Standard Oil group controlled nine tenths of

the refining business; it either owned or controlled in some way every transportation agent in the oil regions; it controlled the terminal facilities in the principal seaports; and it owned or held by lease the majority of tank cars on the chief railroads. The Standard was now the buyer, carrier, manufacturer, and seller of petroleum. The dream of dominating the petroleum industry had taken only twelve years for its fullest realization. But peaceful domination was far away. Supremacy had been acquired only through hard struggles, and other hard struggles must be won to maintain control.

The Tidewater Pipe Line Company, organized in 1879 by independent interests to transport crude oil to the coast, was the first and most important rival. The Tidewater episode was important, not only because the concern had large resources and made a strong fight, but also because it led ultimately to the material extension of Standard activity and control. The war was carried on mainly through the railroad allies of the Standard, for they were most vitally concerned in its outcome. The pipe line to the seaboard threatened to rob them of the traffic which had become so profitable, and immediately freight rates were cut to kill it. Even to the general public the rates from western Pennsylvania to any one of the leading ports were dropped from one dollar and fifty cents a barrel to thirty and then fifteen cents. Such a fierce struggle could not last long. It was highly profitable to the shippers, while it continued, but it

soon exhausted the resources of the Tidewater Company and forced a capitulation.

This outcome served still further to strengthen the position of the Standard, for it ended the traffic war temporarily and led to the building of Standard trunk lines to the coast. The National Transit Company, a new subsidiary concern, was organized to control the pipe-line end of the business, and, with its seaboard trunk lines completed, the Standard became entirely independent of the railroads which had aided it so long and faithfully. The construction of trunk lines also placed the Standard on essentially the same footing which it now holds. Subsequent events have been confined largely to growth along the lines then laid down and to extending its operations to keep pace with a rapidly expanding industry. Only once since then has an important rival appeared, in the form of the United States Pipe Line Company, organized among the independent operators by Lewis Emery in 1890. Every possible obstacle was placed in the way of this line during its construction, even to an armed encounter between employees of the pipe company and those of a New Jersey railroad which was trying in all ways to block the route to the coast. The line, however, was eventually put through after many delays and difficulties, and now, under the operation of the Pure Oil Company, it, with its modest five or six hundred miles, is the sole pipe-line competitor of the great Standard system in the eastern part of the country.

Serious legal difficulties as well as business rivals have also constantly beset the path of the Standard interests. In 1872 and in 1876 its methods were investigated by committees from Congress. Bitter complaint against its monopoly was made by the independent operators of Pennsylvania in 1878, with an appeal to the governor for some legislative action. Public feeling ran so high that officers of the company were hanged in effigy in Titusville, and processions of masked men besieged the company's local offices. The Standard Oil Trust, a new form of organization adopted in 1882, was deprived of its charter and dissolved by the Ohio courts for various offenses ten years later, while recently it has received widespread consideration as a violator of state and federal laws. Resentment in Kansas was so keen in 1904 that the legislature appropriated several hundred thousand dollars to establish a rival business. In Illinois, Tennessee, Louisiana, Missouri, California and New York, thousands of indictments have been returned on one count or another, one trial for acceptance of rebates resulting in the famous fine recently set aside on technical grounds by the Court of Appeals.

Despite all opposition, however, the Standard has continued to prosper and has persistently followed the same policy of extending its operations wherever oil is found. No matter how great efforts might be required of it in the pursuit of this policy, the company has never hesitated, for only by unceasing activity and overcoming every obstacle

could the Standard control of the business be kept intact.

When the rich McDonald district in southwestern Pennsylvania was opened in 1891, for example, the production rose from 50,000 barrels monthly to over 1,800,000 barrels five months later. The Standard pipe lines, the only ones there, had a capacity of about 3,500 barrels a day at the beginning of July, 1891, when the daily production was probably not more than half that amount. During July, however, the flood of oil appeared, sending the production upward at an unheard-of rate. The Standard had to take care of it; and how well they rose to the emergency can be seen from the fact that in six weeks their pipe-line capacity was increased to over 26,000 barrels and in six months to over 90,000 barrels a day. This tremendous expansion in such a short time meant far more than the mere placing of equipment and setting it to work. It meant also work night and day in boiler shops and rolling mills to turn out the necessary tanks, boilers, engines, pumps and pipes; stupendous efforts which no number of small concerns could have commanded satisfactorily.

Control of transportation facilities has always been one of the chief sources of Standard success. Railway rebates and discriminations gave the Standard its original hold on the business. By allowing it to sell for prices where others could not make a profit, the Standard practically held control of transportation between the refinery and the con-

sumer. Later on in its development, the acquisition of pipe lines added also the control of the equally important link between the refinery and the producer. This policy of controlling transportation has necessitated the addition of pipe line after pipe line, until now the Standard owns over 40,000 miles of pipe, covering all the fields from Kansas to the coast, with great trunk routes to the refineries. The one important line in California belongs to the Standard. Only in the Gulf field is there any extensive competition by independent pipe lines.

This complete control of crude-oil movement has been used in a variety of ways to stifle competition, but principally through the refusal to transport or sell crude oil to independent refiners. State laws in general have declared the pipe line to be a common carrier, hence legally required to transport oil for any shipper requesting the service. Being the only carrier has also made the Standard the chief buyer and hence the chief seller in the Eastern localities. It has, however, frequently been accused of refusing absolutely to sell crude oil to outside interests or having so restricted the amount as to make refining unprofitable. Furthermore, by refusing to deliver at the required point, by charging outrageous rates, or by refusing to carry at all, in direct defiance of the law, the Standard is said to have prevented independent concerns from securing oil of outside dealers.

The pipe line has been an equally valuable aid to

the Standard in developing its efficient arrangement of refineries and distributing systems. No refiner who is dependent on railroad transportation for his crude oil can nowadays hope to be an important factor in the business. Refiners not affiliated with pipe-line service must locate near the wells from which they can buy their supplies and, as a result of this location, they find themselves either restricted to the small markets of neighboring districts, or else forced to pay comparatively heavy freight charges on the long hauls of distilled products to the leading markets. Through its pipeline system the Standard, on the contrary, has been able to choose strategic positions near important industrial and commercial centers for the location of its refineries. It has been possible, at the same time, to replace many small establishments by a single plant where all the economies of large-scale operations can be secured.

The large refineries are fully equipped to perform all sorts of subsidiary operations. Barrels and boxes are manufactured by the hundreds of thousands from lumber grown on the company's own tracts. Thousands of tin cans for "case oil" are turned out daily without a human hand touching them from the time the sheets of tin are crimped until the completed cans are ready to be filled with kerosene for shipment. Glue, chemicals to be used in refining, paint, giant pumps for its pipe lines, even lamps and wicks are made in the Standard's works. The Standard buys nothing

that it can make as well. Such is the result of concentration.

The two hundred and fifty refineries operated in this country thirty-eight years ago, when the first Standard Company was incorporated, have decreased to less than a hundred. The Standard controls only a score of the largest. Their locations are significant when compared with the original locations of Standard activity. Seven, including the largest two, are located near the important Atlantic ports, New York, Philadelphia and Baltimore, the one plant at Bayonne, N. J., covering nearly a square mile and employing over 6,000 men. A half dozen smaller plants are scattered through the Appalachian region and the Ohio-Indiana field. The huge establishment at Whiting, Indiana, is at once convenient to Chicago and for distributing to the great middle west and south. Others in Kansas, the largest at Neodesha; in Texas, at Corsicana and Chaison; at Florence, Colorado, and at Port Richmond, California, complete the access to every important section of the country and for all lines of foreign trade.

The location of Standard refineries has greatly facilitated the perfection of a system of bulk distribution of petroleum products by means of tank stations and tank-wagon deliveries direct to the consumer. It has, in the same way, been of great assistance in killing competition. Eliminating the middle man by selling direct to the retailer or con-

sumer opens the way to all sorts of price discriminations. Selling at a loss in a competitive market to cripple a rival can then be recouped immediately by charging correspondingly higher prices in non-competitive districts. In the face of such advantages and methods, any rival must have enormous resources at the outset in order to wage successfully the inevitable "oil war," if it desires to extend its operations.

It is remarkable that all through the discussion of Standard power and success there is no mention of a monopoly of production. The so-called anthracite-coal trust owns or controls many of the mines, and the steel corporation controls the richest of the iron-ore deposits. But the "Oil Trust," greater than either, strange as it may seem, has never made any concerted effort to secure general possession of the oil wells. In fact, the Standard had been thoroughly established in its monopoly of the refining business long before it entered this field of activity at all.

The rapid developments of the Lima-Indiana field from 1886 onward, offered the Standard a chance to secure a large interest in the district for almost nothing. The character of the oil made it useless to existing refineries as they had no means of removing the sulphur. The prices were, therefore, so very low that the producers and owners of property were glad to sell to the Standard, which had been steadily carrying on costly experiments in refining in the effort to get rid of the

sulphur and secure a desirable kerosene. Such a favorable opportunity for acquiring valuable property at low prices could hardly be allowed to pass, especially since the experiments promised ultimate success and the Standard secured large holdings. Since then the Standard has continued to be an important producer, other wells having been added from time to time, mainly in the Appalachian and the new Illinois field. The annual output from the Standard wells, however, does not even now represent more than a third or, at the very most, a half the total in these Eastern fields, and probably less than one fifth the total for the whole country.

The reasons for this apparently contradictory policy of struggling to dominate the refining end of the business and neglecting the sources of the crude material are clear enough, and show the wisdom of the Standard management. If it so desired, the Standard could undoubtedly acquire the same degree of control over production as it enjoys over refining and selling, but monopoly ownership of a natural resource would be likely to raise a terrific storm of the most bitter public opposition. By following its present course and posing merely as a buyer and seller of oil, with nothing to prevent the entrance of competitors into the field, the Standard points to its superior ability, efficiency, and economy as the sole basis of its success. All the time, however, it enjoys in fact a very effective control of production through its ownership

of the only efficient means of transportation. The element of risk in production has also been an important factor in influencing the Standard policy. By leaving all the risks of prospecting, drilling, and operating to individual producers, the Standard runs none of the many chances of heavy loss on unprofitable ventures. When everything is considered, owning the refineries and pipe lines is far more profitable and every whit as effective as owning the wells.

The name of the Standard Oil Company commonly suggests to many persons something more undesirable than desirable. In the stress of violent competition, the Standard may have been guilty of many faults, but the impression that it is wholly bad is the work of a few sensation mongers. There is something of good even in the Standard Oil Company. Thus there are many reasons for believing that the development of such a tremendously powerful company has alone made possible strides of progress far in advance of what could otherwise have been expected. The best evidence on this point comes from the foreign fields where industries centuries older have been completely distanced by the progress in this country, while those places in which the example of the Standard in centralizing interests is being most closely copied are rapidly coming to the front.

Only such a company, backed by great resources, could have supplied so promptly the equipment demanded by the many sudden and rapid advances

in production, thereby helping to prevent the loss of large quantities of oil and saving the producer from profitless operation. Only such a company could afford to employ a great force of experts devoting all their time to perfecting old and discovering new processes and products of refining. It is

A Standard Oil Plant in the Far East.

doubtful if many smaller companies working independently could afford to sell their products any more cheaply. Only the immense company can operate plants to manufacture everything it needs, from thousand horse-power triple-expansion pumps down to tin cans and lamp wicks for the Chinese trade. Buying outside means heavier expenses, and hence either lessens profits or raises prices. It

is very doubtful if the existence of a number of smaller competing companies would insure the high standard of quality which is always insisted on by the much-maligned "Trust." Vigorous rivalry, if long continued, is too prone to lower standards and, in the use of petroleum products, of all things, reliability is absolutely necessary for public safety. This reliability must in fairness be credited to the Standard Oil Company.

No less powerful organization could have placed the foreign trade in petroleum products where it is now. Certainly no less power could have maintained, indeed, actually increased this foreign trade against the ever-growing competition of other countries. The Standard is not merely an American concern; it is world wide in its scope and activity. It may have stifled most of the competition at home, but it has also doggedly fought for and kept an immensely valuable trade abroad, thereby affording a ready market for millions of barrels of oil which could find no sale at home, and aiding materially in holding the much-coveted "balance of trade" for this country. It is even an open question whether stifling competition, the chief charge against the Standard, has been such a serious offense after all.

The growth of such a gigantic petroleum industry as now exists in this country, and the success of the great corporation depending on it, have been accompanied by the accumulation of sudden and enormous fortunes. Much has been said of

late years about the excessively high profits of the Standard Oil, and "forty-eight per cent. dividends" has become a sort of call to battle for those who would destroy everything that makes for progress.

The fact is commonly ignored that the Standard capitalization of $100,000,000, in round numbers, does not represent anywhere near the recognized value of the tangible property owned by the company. If the capitalization were increased to half a billion dollars and the present earnings paid in dividends on that basis, no comment would be excited; in fact, Standard Oil would very likely be considered a rather poorly paying industrial stock. Yet not a few of the large business interests of the country at the present time are paying moderate dividends on a capitalization which bears a ratio of not less than five to one to the real value of property owned. Enormous Standard dividends, however, have not been the only source of fortunes in the oil business. Before the Standard idea was even formulated, comfortable fortunes were made in the oil fields, and large fortunes are still being made entirely outside the sphere of that concern. In fact, the idea of large returns is so universally associated with oil operations that the expression to "strike oil" has come to be synonymous with suddenly acquiring wealth. It may be safely said that, first and last, more fortunes have been made quickly through the petroleum business than in any other single enterprise ever developed in this country. At the same time,

it is probably no less true that more fortunes have been lost in unsuccessful oil ventures than in any other kind of industrial operation.

Rich returns have ever been the rule for the ones whose efforts were crowned with success. Heavy losses have borne down still farther those on whom a fickle Fortune refused to smile. Sudden wealth and equally sudden ruin have not infrequently been the double portion of the more adventurous. With few exceptions, however, it has been the successful ones who have made oil history, just as oil was the making of practically every man whose name appears prominently in the chronicles of the industry. Nowhere during the half century is there a leading figure coming to the industry with important resources already at his command; on all sides the guiding spirits are those which have "grown up with the business." Nowhere is this fact more strikingly illustrated than in the group of men dominating the Standard Oil Company. John D. Rockefeller rose from an assistant bookkeeper in a Cleveland commission house at a salary of four dollars a week; H. H. Rogers, from a clerkship in his father's store at Fairhaven, Mass.; John D. Archbold, son of a Methodist minister, from the general store at Salem, Ohio; Daniel O'Day, the great trunk-line organizer, from the freight yards in Buffalo; Samuel C. T. Dodd, the keen-witted legal adviser, father of the trust, from a printer's office in Franklin, Pa., where he worked to earn his way through college.

While these men were still laying the foundations of later success, others belonging to the same class as themselves were rolling in wealth. When the oil boom in Pennsylvania was still in its infancy, incomes of $1,000 a day were regarded as fabulous wealth, as indeed they were in those days before the modern age of millionaires. Yet such profits were not entirely unheard of in the years following 1860, when crude oil often sold for several dollars a barrel, and numerous wells averaged hundreds of barrels a day. It is easy to understand therefore, the irresistible temptation which drew so many young men from the four points of the compass to try their luck in the new venture, with its unlimited opportunities to rise rapidly. Those were the days of the spendthrifts and prodigals, when money flowed lavishly, as easily gained profits were spread right and left with open-handed generosity: the days of the "Coal Oil Johnnies."

The original of this famous figure in oil history was in a way typical of an early class, indeed almost of an early condition in the oil regions, but many of the marvelous tales about him, handed down to later years, are impossible, distorted products of fertile imaginations. "Coal Oil Johnny," for such a person actually lived, was one John W. Steele, the adopted son and heir of the widow McClintock, on whose farm a number of the early productive wells were located. By her sudden death in 1863, Steele, then barely of age, found himself the possessor of apparently unlimited

wealth, which the wells were pouring out for him in an endless stream. It is scarcely to be wondered at that such unexpected riches turned the boy's head and started him out to spend his money in a way which soon led to the wildest dissipation. For a year he was the sensation of the region, where men were living daily in an atmosphere of constant sensations. For a year self-avowed friends openly robbed or secretly swindled the unsophisticated youth, until, with money and property gone, the friends left him to seek a living as baggage master at a small local station on the Oil Creek Railroad. The unwelcome notoriety which he had gained, however, soon drove him into the great unquestioning west, and removed from the oil fields its most spectacular character. Some chronicles would have it that Steele spent millions of dollars in his brief course as a spendthrift, but it is highly improbable that his whole squanderings much exceeded half a million.

"Coal Oil Johnny" represents one type of man which the oil business produced, his sort being confined largely to the group of early well owners, to whom great profits came quickly: men of whom much has been told and written, but whose service to the petroleum industry was small. The other type is represented by the sober habits and industrious lives of such men as Standard Oil has enlisted in its service. To these men, working hard in the interests of oil refining, wealth came more slowly but all the more surely. To them the pro-

ducer has always owed much, for their untiring efforts to increase the consumption of petroleum products have benefited both refiner and well owner alike. Many men have been arrayed in the rank and file of oil operators, each contributing in his own small way to the progress of a vast enterprise. Due credit must be given to the few trail blazers, Kier, Eveleth and Bissell, Drake and his faithful helper, "Uncle Billy" Smith. But the real makers of oil history are to be found, in general, among the men most intimately associated with its greatest corporation. The man who discovered the rich McDonald field, for example, stands in the same position as a scout who locates from afar the camp of the enemy; the corporation taxing its utmost strength to meet the emergency, stands as the powerful army which gains the victory in battle and follows it up to the fullest advantage. Behind this army have stood always the same small group of masters of strategy and resourcefulness, the guiding spirits of oil destinies in this country.

CHAPTER XI

BAKU—OUR ONLY RIVAL

The Russian oil fields on the western shore of the Caspian Sea are the only ones, so far as is now known, where it would be possible to approach the magnitude already attained by the industry in this country. In fact, before the great discoveries in California and Texas, Russia actually did lead the world in petroleum production for a time, and might still do so perhaps, if domestic uprisings had not dealt several severe blows to the industry. Yet the two regions, Russian and American, are as unlike as possible. The American production comes from relatively large areas scattered over the entire country. The Russian production, on the contrary, comes from an area of only a few square miles, containing less than 3,000 wells, or only about one-tenth the number operated in the single state of Indiana five years ago. Nowhere else in the world has any equal area yielded such enormous quantities of oil for such long periods of time. In this one respect, at least, not even the United States can surpass the Russian district.

The modern Russian industry centers at Baku,

on the Apsheron peninsula, where Persian legend says that petroleum workings have existed for nearly three thousand years. The period of Russian possession, however, extends back only to the beginning of the last century, since which time more or less oil production has continued. Most of this Russian period of ownership is covered by the imperial monopoly, the revenue from the oil workings being turned into the royal treasury. Part of the time the government worked the oil springs, though, for the most part, the government contented itself with regulating the selling price of the oil and receiving a bonus on all sales. The actual operations were then farmed out for a term of years to the highest bidder or to some court favorite, who paid for the privilege a stipulated annual revenue. Under this system the production rose as high as 1,500,000 gallons a year, yielding the government an income of 160,000 roubles.

This imperial monopoly seriously hampered the proper development of the industry until about 1872, when the government decided to open the region to private enterprises. The district was accordingly surveyed in plats of twenty to thirty acres each, their values appraised, and they were then sold to the highest bidders. Much attention had already been attracted toward the field by the previous developments and the possibilities in sight, so that the bidding was often spirited. Plats officially appraised at a few roubles each were

taken eagerly at a price two or three thousand roubles higher, thus following out the rule of artificial land values created by prospects of oil.

The real beginning of the Russian industry dates from this admission of private enterprises, but the general condition of affairs at Baku for some years after 1872 makes a sorry comparison with the flourishing business then firmly established in this country. The primitive methods of open pits and shallow dug wells were still in vogue; in fact, drilled wells had apparently never been heard of. The oil was tediously pumped out by hand or by horse power and stored in underground pits. What refineries there were hardly deserved the name, on account of their inferior products. The lighter products of distillation had no important uses and were frequently allowed to run into the Caspian, while the residuum or astatki, entirely useless, accumulated at the refineries and was periodically disposed of by burning in open pits. The only means of shipment were overland in the slow, clumsy, high-wheeled native carts or *arbas,* or by boat across the Caspian and up the Volga, thus greatly limiting the market. Barrels in a country completely devoid of timber cost so much that they were often more valuable than the contents. While to complete the burden, the government imposed an excise tax on the oil, and brought the whole industry to the verge of collapse.

It is not strange, considering the adverse circumstances, that the Russian industry rose slowly.

The real cause for wonderment is that it developed at all. Before 1880 the entire output scarcely ever exceeded 3,000,000 barrels a year. At that time, the Pennsylvania field alone was producing ten times as much as the Russian wells, and American oil was being carried thousands of miles to be sold in the cities of western Asia, in St. Petersburg and Moscow, under the very eyes of the Russian operators. But out of the seemingly hopeless depression there gradually loomed signs of salvation.

American methods of drilling and boring were introduced and paved the way for increased production as soon as other conditions were favorable. Astatki was successfully used as fuel, and the popular clamor against its dangerous character was so conclusively disproved that it was adopted for practically all the craft on the Caspian Sea. The lighter products began to find various uses in manufacturing processes, materially improving conditions for the refiners. The government removed the burdensome excise tax. Perhaps most important of all was the entrance of the Nobel brothers into the field, bringing with them western ideas, ingenuity and energy. These men of Swedish descent, seeing into the future, realized the possibilities of the Russian industry and immediately turned their efforts into improving every aspect of the business: the methods of production, refining, transportation, and securing markets for their products in competition for the lucrative

trade which the Americans had enjoyed unmolested so long.

When the Nobels entered the refining business in 1875, they realized clearly that the existing transportation facilities would never allow any profitable development and that the first thing to be done was to devise something better. All handling of crude oil between the wells and the refineries was done in the clumsy, high-wheeled, native carts, driven by Tartars and Persians. Scarcely a track in the whole district was fit to be called a road, and every rain temporarily stopped all transportation. The native drivers often struck at the busiest time of year, making a condition of affairs far worse than there had ever been in the Pennsylvania fields. Baku had no railroad connections of any kind; in fact, no railroad approached within hundreds of miles of the place; the nearest seaport was over 500 miles away and, for all commercial purposes, as inaccessible as if it had been ten times as far; foreign trade was, therefore, entirely out of the question; the only access to domestic markets was limited to the water route through Astrakhan, via the Caspian and the Volga river, and even that outlet was closed from November to February of every year by ice in the North Caspian ports and in the river.

With so many handicaps to overcome, none but the most resolute would have dared hope for large successes. The American success with pipe lines offered a solution for part of the difficulties; and

the first line, eight miles long, was built by the Nobels to supply their refinery. The line proved to be such an unqualified success, in spite of the opposition, that others were quickly laid, while the idea of a trunk line to the Black Sea was widely discussed. Such a line would undoubtedly have followed soon if it had not been for unyielding government opposition.

The entire absence of any means of export trade by sea meant that practically the whole consumption of oil outside the immediate Caspian district must be confined to Russia, and to those localities in Russia accessible by the Volga, its canals and tributaries, and by the Russian railroads. An elaborate distributing system, therefore, was the only means which would build up a wider market and allow the industry to expand. The Nobels again led the way. A large fleet of tank steamers was introduced to carry the products of their refineries to the mouth of the Volga, where transshipment was made to river barges for shallow-water navigation. Important distributing centers with great storage reservoirs were established in convenient places, where large supplies brought by barges via Astrakhan and then by rail from Tsaritzin could be accumulated during the season when the ports were ice free.

From such important points as Orel, Moscow, St. Petersburg, Warsaw, and Saratoff, the oil was readily distributed throughout the surrounding country to supply the heavy demands of the win-

ter season. Occasionally shipments following this route found their way across the frontier into Germany or from Riga across the Baltic to Scandinavia. But the main consumption was at home. Kerosene was in great demand wherever it could be secured, while astatki, after it had been adopted for fuel for all vessels on the Caspian, began to be used generally on locomotives, and, by its cheapness and abundance, it led many industrial establishments to locate in the Volga district. At every point the Nobels were the leaders in placing the business on a profitable basis, their persistence in sticking to innovations never failing even in the face of opposition from every other operator in the region, and generally being rewarded sooner or later by the silent approval of direct imitation.

The building of the Trans-Caucasus railroad in 1883, connecting Baku with the port at Batoum on the Black Sea, for the first time offered a convenient outlet to the sea and opened a vast new field for the activities of the Russian operators. Where Baku oil before had been obliged to go over 2,000 miles to Riga on the Baltic to be shipped by sea, it could now go only 560 miles to Batoum and reach a "tidewater" port. The encouraging prospect of building up a profitable foreign trade gave the whole industry a new lease of life. Russian production immediately began to rise.

About the same time the Rothschilds firm, a powerful English concern, appeared in the field with the avowed object of "producing, refining,

transporting, and selling Russian petroleum." Wild rumors at once whispered that they intended to monopolize the entire industry and great consternation prevailed among the smaller operators. These fears proved ungrounded, however, for, like most of the investments of English capital there, the advent of the Rothschild company was of decided benefit. The firm greatly assisted the refiners both by extending the market for Russian exports and by buying kerosene in large quantities, frequently paying in advance. These practices often carried operators over impending crises and made it possible to work when they otherwise could have done so only at a loss.

The inevitable outcome of these progressive steps is easily foreseen. Batoum rapidly became an important commercial town and one of the greatest oil ports in the world. Enormous storage tanks were established, a fleet of tank steamers was necessary to carry oil regularly to European ports, while tramp steamers from all nations began to appear in the harbor. By 1885 Russia had to be considered as a rising factor in the world's oil business, although the United States was still producing nearly twice as much as all others combined. The railroad, at first fully capable of handling the oil traffic to Batoum, was quickly outgrown. Abundant capital, both Russian and English, stood ready, eagerly waiting for permission to construct a pipe line parallel to the railroad, for trunk lines to the seaboard in this country had enjoyed un-

qualified success and had greatly stimulated the whole industry. There was absolute certainty of success here, too, but the authorities, fearing a decrease in the revenues of the railroad, the profits of which were guaranteed by the government, persistently refused to grant the necessary concession.

Finally, however, in 1897, the congestion of traffic had become so serious a problem that the old conditions could be tolerated no longer and the government itself undertook the construction of a pipe line over part of the route where a steep grade had always hampered the heavy traffic. The early example of the Nobels had, after many years, borne valuable fruit. This original section of pipe line was later extended, until now a continuous line about 600 miles long connects Baku with its chief port. Batoum, as a result, has since come to be an important refining center as well as the shipping point, thus again following the example of the American industry in piping the crude oil and making the refined products at the point of shipment.

The last important addition to the transportation facilities was completed in 1898, when the main system of Russian railways was connected with Baku by a line along the Caspian shore. The water transportation during the open season is so much cheaper that the old régime continues to a large extent, but the main advantage of the railroad is in affording ready means of communication in winter.

The location of Baku has, as a result of this gradual evolution, ceased to be a disadvantage. Quite to the contrary, its position now opens to it enormous areas where no other countries can successfully compete for the trade. The Caspian and Volga routes would be valuable assets for any oil field, affording as they do, for eight months of the year, thousands of miles of the cheapest kind of transportation to the centers of domestic consumption. The Trans-Caspian railway gives access to the market of immense areas in the provinces of Western Asia. The direct connection with the Black Sea offers unlimited possibilities abroad.

Probably more than in any other field in the world, the development of the Russian industry has depended on these transportation facilities. Within one year after the railway to Batoum was opened the production increased by over 4,000,000 barrels, where prior to 1880 the total production had rarely risen to a total of 3,000,000 barrels. Similar expansion continued during the succeeding fifteen years, rapidly advanced Russia to the position of a close rival of the United States, until this country was finally left far behind as regards the the amount of crude oil produced. But the most surprising part of it all is that this whole phenomenal growth came in the short space of twenty years, reckoning from 1878, the year when the removal of the government tax first made profitable operation possible.

One other leading factor which has aided greatly

in the Russian expansion is the character of many of the wells. The introduction of American methods of boring was immediately followed by the frequent striking of gigantic gushers. Tapping the deeper strata, which the dug wells could not touch, almost invariably yielded oil in unheard-of quantities. Nothing approaching these oil fountains had ever been seen before; in fact, even the most conservative accounts of the wonderful strikes seemed so incredible that the truth of the reports was generally doubted in this country; and the Russian industry was badly demoralized for a time by the uncontrollable, unsalable quantities obtained. Wells spouting fifty, a hundred, a hundred and twenty-five thousand barrels a day were common occurrences. The heavy Baku oil carries with it a great amount of sand and often the most violent of these gushers destroyed or seriously injured surrounding property by burying it under a deluge of sand and oil. Roads and houses were flooded with oil, wells were blocked, and roofs gave way under the load of sand, while fearful conflagrations resulted from accidental ignition of the far-reaching spray or gas. But, in spite of the losses which have been incurred thereby, this flowing character results in a very much higher yield per well, approaching 100 barrels a day, or twenty to thirty times the average of wells in this country.

By 1900 the Russian wells had increased so rapidly that they were yielding more than half the world's supply of crude oil and exceeded the out-

put in the United States by more than 12,000,000 barrels. The succeeding years, however, brought in the enormous quantities from Texas and California, doubling the previous figures for the United States. At the same time domestic difficulties gave Russian expansion a severe setback. The turmoil incident to the war with Japan and civil uprisings affected the oil business perhaps more than any other industry. The accumulation of enormous stocks in storage, with no market, brought on a crisis just when the boom was well under way. Then followed the race war and massacres between Armenians and Tartars of the Caucasus district, in 1905, during which sad havoc was wrought in the oil fields. Many of the wealthy and prominent Armenians were important oil operators and the Tartar frenzy was directed against their property as well as their persons. On all sides derricks, workshops, offices, and laborers' houses were wrecked. Fires were set and spread unchecked in all directions. In some sections the destruction wrought during the reign of terror was well nigh complete. Over a thousand wells were destroyed in the different districts; hardly more than half that number remained after the trouble was over, reducing the production to about one third of its former extent.

The work of repairing the damage, however, began as soon as the uprisings were quelled, the government making loans to those who had suffered the worst losses, in order to hasten as much as pos-

sible the regeneration of the industry. Already the production has begun to increase again. It has also been discovered that the productive localities are of far greater extent than the area formerly developed, hence there is every reason to suppose that the output will soon reach and surpass its former annual rate. In spite of its burdens, the Caspian district seems destined to be a persistent rival of the American oil fields.

The successful development of this Baku industry is in many respects the most romantic chapter in the whole story of petroleum. Whatever has been accomplished there, has been done in the face of difficulties and natural obstacles unparalleled in any other oil field in the world. Situated in a desert, and separated by thousands of miles from the important centers of European and Asiatic population, it has had to create markets and means of reaching them before any growth was profitable. Drilling the wells even by the best modern methods often entails difficulties and expenses many times in excess of the most costly operations in other localities. Ordinary pumping is impossible on account of the sand in the oil, so that in non-flowing wells, it is necessary to use a cumbersome bailer, consisting of a long hollow tube, with an automatic valve in the lower end. Gigantic gushers not infrequently have brought to the operators practical ruin instead of riches, through the damage done. Every stick of timber used in the industry down to the very staves for barrels had to

come, for many years, hundreds of miles down the rivers and across the Caspian. Even water for the boilers is scarce, that of the Caspian being salt and unsatisfactory. On top of it all has been the worthless character of the only labor to be had; unreliable, inefficient, ignorant Orientals, imposing a constant burden on the industry.

Yet in the face of so much that is disheartening, a great industry has been developed by sheer persistence; and Baku now links the dim past to the most advanced ideas of to-day, sharing alike in Oriental and western civilization. This ancient desert town has risen from obscurity to world fame. From the home of medieval Persian Khans, it has come to be the home of modern oil kings—Armenian millionaires who, perhaps, can scarcely read or write. Modern streets, stores, office buildings, electric lights and telephones, factories, and smoking chimneys, show the influence of the West. In strange contrast stands the ancient city and all-pervading spirit of the East; the clumsy water cart and the camel train; the palace of the Khans, the mosques and the towers of romantic legends. It is everywhere a confusion of the old and the new, of East and West on the threshold of modern civilization. Petroleum has performed many wonders, but none greater than this.

The United States and Russia stand alone in the petroleum industry, the latest statistics crediting them with seven eighths of the total for the world.

Of this, the United States produced five eighths, and Russia the other two eighths. A great many other countries produce some petroleum, but only a few of them have attained any real commercial importance. The Dutch East Indies, Galicia, Roumania, India, and Japan have risen to the distinction of exceeding 1,000,000 barrels a year, while Canada, Germany, Peru, Italy, and various others eke out a million between them. Yet two of these countries, India and Canada, have each enjoyed for a time the honor of being probably the greatest producing locality in the world.

The Burman oil fields in the Irrawady valley were supplying oil to the whole of the empire befor the beginning of the last century, and some time after that the production was estimated at several hundred thousand barrels yearly. This quantity is many times greater than was ever reached by the Russian fields during the early days of the government monopoly, so that the Burman supply a hundred years ago was undoubtedly the greatest in the world. At the present time, the industry is carried on in two localities, the largest in the Irrawady valley south of Mandalay, the source of the so-called "Rangoon oil," the other including the Arakan Islands and a section of the neighboring coast. The combined production in the two areas is about equal to that of the Louisiana field, the recent introduction of modern appliances having tripled the output inside of three years.

Oil wells were sunk in the western part of the province of Ontario from about 1857 onward, and a few years later this portion of Canada was probably the most productive region in the world. Some of the wells yielded six to seven thousand barrels a day in 1862, the supply being so great that there was practically no sale and "millions of barrels flowed off into the creeks." But the leadership was short, for the Pennsylvania fields soon rose to much greater prominence at the time of the Pithole craze, while the Canadian supplies steadily diminished. The yields in recent years have been only a fourth or a fifth of what a single well was producing in the early days. Indications afforded by developments in the Northwestern provinces, however, point to the possibility of Canada in the future rising once more to something like its original rank.

The commercial development of the petroleum deposits in the Dutch East Indies is entirely of recent origin, in spite of the fact that the natives appear to have used it for centuries. In view of the Dutch system of colonial administration for revenue, it is strange that the oil fields were practically untouched until about twenty years ago in Java and Sumatra, and ten years ago in Dutch Borneo. The deposits in Sumatra are located on the northeast coast, and in Java on both north and south coasts; but all of these fields are less important than the South Borneo district, which began with a giant gusher in 1898. The rapid growth

of the industry in these Dutch possessions has, in the last decade, placed them ahead of the much older fields of Galicia, Roumania, India, and Japan. The abundance of the available supplies has, of course, had much to do with this encouraging growth, but the rational system of development has been an equally important factor. With characteristic Dutch foresight, the most up-to-date apparatus was brought from the United States before work was begun, and all the important developments were undertaken by large interests having sufficiently abundant capital to carry through the necessary trial borings. Few indeed are the places where oil prospecting has been undertaken in such a thoroughly businesslike manner. Success was almost inevitable under the circumstances and the Dutch supplies have deservedly come to be a decidedly important factor in the oil trade of the Orient.

Galicia and Roumania both antedate the United States in the oil business, Galicia at least having been the scene of distilling operations a hundred years ago. The Canadian system of boring wells was introduced into the Galician field at an early date, but bored wells were not general until comparatively recent years. Even now some of the supply comes from the old shallow wells dug by hand. The Roumanian localities especially were hampered by the mountainous character of the country with bad roads and railroads entirely wanting. Neither country had risen to a production of 1,000,000 barrels annually until about twelve years

ago, when new discoveries in Galicia rivaled for a time the rich strikes at Baku and in this country. The output was more than doubled, rising to nearly 2,500,000 barrels in 1896, since which time it has increased over threefold.

The important Roumanian development has come entirely within the last ten years as the result of introducing bored wells, pipe lines, and modern refineries, in which American capital was largely interested. Now the Roumanian production is ten times greater than it was a decade ago. Then it was only a third as much as the Galician yield; now it stands a close second, but the yield of neither country is equal to the output from the old, worn-out localities in Pennsylvania. Neither district has important markets outside of European countries.

Japan is the only other country in which the industry has risen to the dignity of producing 1,000,000 barrels in a single year, or what would be about the total from two-score average Russian wells. The Japanese industry has been in existence over 1,200 years but it had to wait for American operators to raise it out of the rut where it had lain dormant for centuries. In spite of its recent developments in answer to this American stimulus, however, the Japanese industry is decidedly insignificant, even from the standpoint of domestic consumption. At the present time the imports of American kerosene alone exceed the whole yield of crude from the local industry. Japan is

truly a nonentity in the petroleum business, when compared with other even third-rate countries.

The six countries, United States, Russia, Dutch East Indies, Galicia, Roumania, and India, produce approximately ninety-nine per cent. of the world's total supply of petroleum. A score of other places contain petroleum deposits of varying extent, and small quantities are secured for local consumption in most of them. In this class are found Mexico, Germany, Peru, Italy, Turkey, Persia, Egypt, Algeria, the Punjab, New Zealand, and Formosa; some of these places may become great producers in the future, but at present they do not begin to supply more than a small portion of the purely local needs.

The United States so far stands in a class entirely by itself, having led the world for nearly half a century, unbroken except for the three years of Russian leadership just before the Texas and California developments began. Russia alone, at the present time, can be regarded as a worthy rival. None of the other countries have as yet passed the stage which this country had reached forty years ago. Discoveries similar to those in Texas and California may, of course, at any time, raise some obscure locality from insignificance to the foremost rank in the space of a few years. The petroleum industry is, above all else, a thing of sudden changes. Yet, in the light of all present knowledge, Russia is the only rival which appears likely to threaten American supremacy in the immediate future.

CHAPTER XII

THE STRUGGLE FOR THE WORLD'S TRADE

TWENTY years ago an Englishman described the striking of the famous Droojba gusher at Baku, concluding his description with this highly amusing statement: "After that, America, the country of 'big' things, may well hide her diminished head. There is really no comparison between the two oil regions. The yield of Baku licks America as completely as the yield of America licked the shale oil yield of Scotland. The Americans are no longer in it." The American industry, however, has persistently refused to stay "licked" either in the extent of its production or in the expansion of its activities. An unceasing campaign, waged in all quarters of the globe to secure and maintain important markets for the products of American petroleum, has given this country a greater industry than all the rest of the world combined.

This struggle for the world's trade has been one of the chief features of the industry in recent years, the American domination of foreign markets having been entirely undisputed until after the completion of the Caucasus railroad and the rise

of Baku about 1883. The American export trade in petroleum products had then been established more than twenty years and included practically every important country in the world. The foreign trade from this country really dates from the latter part of the year 1861, when the shipping firm of Peter Wright & Sons, of Philadelphia, created a sensation by announcing the chartering of a brig, the *Elizabeth Watts*, to carry a cargo of oil in barrels to London. Some odd shipments of a few barrels or cases had been sent abroad previously, largely through the efforts of the American consul at Antwerp, but this was the first full cargo to leave an American port.

The sudden arrival of such a quantity of petroleum in the British market caused a slump in prices so severe that the shippers lost money on the venture. The experiment ultimately proved a good investment, however, since it sufficed to introduce the oil and create a demand for it. Other cargoes followed this lead; shipments increased rapidly; and new regions were tried one after another with such universal success that within two years oil was being sent to practically every port in Europe, to Egypt, the Orient, East Indies, Australia, New Zealand, and all the countries of the Western hemisphere. From the first small cargo carried by the *Watts*, the exports had grown to nearly 800,000 barrels in 1864. This growth is all the more remarkable in view of the facts that the total production of crude oil then barely

exceeded 2,000,000 barrels annually, and not a railroad or a pipe line existed in the oil fields of western Pennsylvania, while all commerce from Northern ports was more or less hampered by the activities of Confederate cruisers.

Great Britain, France, Netherlands, and Germany were the largest buyers, though fully half the total was distributed in smaller amounts among fifty or more other districts. The Americans were wisely laying a broad foundation for an immensely profitable trade, and gaining firm footholds which were to prove invaluable in subsequent competition. But no ripple of the coming struggle was yet visible. The world, quickly alive to the advantages of the new means of artificial light, continued to demand constantly increasing quantities of oil. Increased production in this country steadily rose to meet the new requirements. Tank cars, then pipe lines and tank steamers lent their aid in facilitating foreign-trade development. The seaport refineries sprang into foremost prominence and the American shippers prospered exceedingly. By 1870 the shipments had risen to over 2,500,000 barrels and ten years later they had again increased fully fivefold. Half the output of the American wells was finding its way far and near to foreign consumers of every nationality.

The flourishing Scotch and French shale-oil industries had been practically killed by the cheapness and superior qualities of the American kerosene. But the best idea of the complete control

of the illuminating-oil market enjoyed by the American shippers appears in the trade to Russia and Asia Minor. Almost to the very time when the Caucasus railway was opened, Tiflis, less than 350 miles from Baku, was using American kerosene which had to be carried over 8,000 miles.

In the early eighties the awakening Baku opera-

A modern tanker: the chief factor in the struggle for the world's trade.

tors began their attempts to introduce Russian oil into the important trade of Smyrna and other cities of the near East. Shipments made via Batoum had to travel hardly a third the distance covered by oil from this country, yet the American representative in Smyrna, as late as 1884, assured the operators that there was no cause to fear any injury to their interests.

In Russia, too, the Americans had introduced their goods successfully almost to the very doors of the Baku region. Throughout western Russia the merchants found it cheaper to get their oil from America rather than from Baku. Whole cargoes were sold in Moscow, one of the most important markets in the country, and easily reached by the Volga route from the Caspian, while St. Petersburg took over 100,000 barrels a year.

Signs of an impending struggle, however, began to appear soon after the advent of the Nobels at Baku. The stress of circumstances which had kept down the Baku industry so long was gradually relieved. Baku operators were determined to have their rightful share of the oil trade. The Americans for the first time had a rival, a rival against whom they have had to struggle ever since, in increasing competition for the big markets of the world.

All the advantage, of course, was at first on the American side, controlling as it did the whole oil trade, even to Russian centers themselves. The American industry was also thoroughly established, conducted by a powerful corporation, possessing every known facility, and determined to continue its domination of the oil business. Without the Standard concern, or a similar concern, the American interests in foreign markets would certainly have fared badly in the years since 1885. Individual companies could never have successfully established such a comprehensive and efficient sys-

tem of transportation and distribution to cover the whole world. Smaller companies working separately could never have waged such a successful war for the oil trade under the very shadow of Russian territory. Great capital has always given the Standard its chief advantage in the struggle for foreign trade; enormous resources have been the keystone of its success there no less than at home.

Less powerful interests could scarcely have afforded the time spent and expense incurred in pushing the trade as the Standard did from 1879 onward. The Standard leaders believed that great as the growth of the oil trade had been, it could be made still greater, if the right methods were adopted. With their usual wisdom they proceeded to investigate before acting and representatives were sent to all parts of the world to study and report on the existing conditions. One important outcome was the breaking down of much local opposition, removal of official boycotts, and repeal of absurd duties and restrictions, which had completely excluded the oil from numerous Oriental districts. Local officials, personally interested in the sale of native oils for illuminating, had in many cases, made the use of petroleum a capital offence, because it threatened their own revenues. A Hindu would never trade with a Mohammedan agent or vice versa, while both hated a Christian, yet native labor was necessary in extending operations on account of the multitude of languages spoken; and the solution had to be worked out on the spot. All

through the East a multitude of such difficulties were overcome, in fact, are still being met and overcome, in expanding the market for American products. How it has been done in the face of deep-rooted Oriental prejudices and suspicions is the most wonderful part of all.

No smaller concern could have taken advantage of the innumerable economies, large and small, to cut the cost of production and make it possible to place the oil in the markets of Europe or Asia as cheaply as it can be done from Baku or from Borneo. To do this the great marine department of the Standard Oil Company has been necessary, making a connecting link between the shipping points on our coast and a distributing system in many foreign countries exactly duplicating the one here. A fleet of four-score steamers and sailing vessels, as well as a host of tugs and barges, has been organized by the Standard to carry oil in bulk, and dozens of other vessels are chartered annually from private owners. Bulk carriage has been half the secret of the success abroad as well as at home.

Storage stations, or main distributing centers, have been established at seventy places in Europe alone. These central stations and a score of refineries supply literally thousands of interior depots and selling agencies, by means of tank barges, cars, and wagons. The same policy has been pursued elsewhere, East and West, North and South. American oil meets Burmese oil in Mandalay. Tin

cases, made in the refinery at Bayonne or Philadelphia, find their way to the native huts of Borneo and the Celebes; or, adorned with a dragon, make strong appeals to the Chinamen's fancy.

The Standard admits no limits to its field of operations, except the limit beyond which man cannot penetrate. No region is so remote, no route so

Tank Cart, Osaka.

long or hard, no mountain pass so high, that Standard oil may not find its way there in answer to a regular demand, until petroleum products have a wider sale than any other article of American commerce. Everywhere the Standard has won its way first by carefully studying conditions to be met and then adapting its methods to the requirements of the individual locality. A typical example comes

from the Chinese trade, where the dense population held out alluring prospects if the market could be developed. The great mass of natives, living most humbly, could afford to use oil only if a cheap lamp were available. Local tinsmiths made rude metal affairs which were almost worse than none, for the light was poor, and frequent explosions prejudiced the native minds against kerosene. The Standard quickly saw that successful trade development depended on first supplying the general need for an efficient lamp. Experiments soon indicated the most desirable type to meet native conditions, every care being taken to make the article as perfect as possible at a minimum cost. The Standard then added another to the long list of its activities and began the manufacture of both lamps and wicks on a large scale. As fast as they could be made, hundreds of thousands were shipped to the East where the Standard agents were directed to sell them at a price equal to about half the cost of actual manufacture. Still this proceeding was excellent business policy because every lamp sold at a small loss meant a demand for so many more gallons of kerosene to be sold at a good profit. This is the way the foreign trade has been extended in the battle to secure and retain markets for American oil.

For this country the Standard Oil Company has borne the brunt of this great commercial battle. Baku has been its leading opponent: America versus Russia in a conflict still unsettled and now

more acute than ever before; a conflict in which success has not always crowned the efforts of the Standard, despite its enormous resources and almost unlimited power.

The first reversal suffered by the Americans was only to be expected; being driven out of the Rus-

Crossing the desert with American case oil.

sian market was inevitable from the very moment that modern progress began at Baku. The Russians speedily accomplished this result by two means; first, improving the Baku refined product until it was a satisfactory substitute for the high-grade American oils, and second, imposing a heavy tariff on all petroleum imports. The Nobels were largely instrumental in raising the standard of re-

fined products, and, with them to push the trade, this securely protected home industry soon commanded the entire Russian market. Imports of American products were reduced from thousands of barrels to a few hundred gallons or cases of special brands, and then to almost nothing. No company, however powerful, could have contended successfully against a great and growing industry in its own country, protected by an absolute tariff barrier of sixteen cents a gallon.

About the time the exclusion of American oil from Russia had become an accomplished fact, the opening of the Caucasus railroad and the advent of the Rothschild firm at Baku gave the signal for the Russians to reach out for foreign markets as well. American consuls at various Old World ports began, about 1885, to report the appearance of Russian oil in small quantities: fifty barrels here, a hundred barrels there, from England to Asia Minor. The Rothschild firm organized a distributing business in Great Britain, long one of the chief strongholds of the American foreign trade. The Nobels soon followed their example, and the imports of Russian oil into Western Europe began to appear threatening.

American exports of petroleum in 1890 had risen to nearly 20,000,000 barrels, at least one fifth of the total going to a half dozen leading European ports. Rusian exports at that time to these same ports equalled hardly a tenth of the American quantity. Following its usual custom, however,

the Standard promptly cut prices to kill this rising competition. Cutthroat methods had sufficed to put the Standard in complete control of the industry at home, but it was not so effective when applied several thousand miles away to a rival industry like that of Baku. Despite every possible effort to prevent it, the exports of Russian oil continued to increase from year to year. The element of distance and geographical position was a factor which no system of organization could entirely overcome.

At first in Europe, then in India and in the Orient, Russian oil steadily invaded the markets so long dominated by the Americans. Negotiations were begun to bring about a division of the world's market between the two rivals, the Standard to supply seventy per cent. and Baku thirty per cent. of the quantities taken by importing countries. But Russian prospects were too promising for any such agreement; if they could get thirty per cent. of the trade peaceably they could get more than that by fighting for it. Within fifteen years, the modest beginnings of fifty and hundred-barrel lots to one place were swelled to hundreds of thousands, and the total was mounting rapidly toward 10,000,000 barrels a year. Only 500 barrels of Russian oil found their way to Great Britain in 1883 as compared with over 1,300,000 barrels from America. Fifteen years later the Russian figure had risen to over 900,000 barrels, or fully one third as much as the American imports.

The Russian success in other localities was even more rapid and striking. A very few years were enough for the deluge of Baku oil to break American control in the Levant and in the Mediterranean countries. Austria-Hungary, one of the leading buyers up to about 1887, practically ceased en-

Selling American "bulk oil" on the plains of India.

tirely to be a market after that date, partly as the result of Russian competition and partly through the tariff barrier adopted to protect the infant Galician industry. Importations into Turkey and Greece also dropped suddenly to nearly nothing. The Standard at one time had enjoyed a virtual monopoly of the oil trade to the far East—to India, China, and Japan. Russia first entered that field

in 1887 and immediately proceeded to capture it bodily. So successfully and thoroughly was this done, through the advantage of proximity and ease of shipment via Suez, that the American trade has steadily decreased. Russian imports, on the contrary, have just as steadily increased, until in recent years they have amounted to ten or fifteen times the quantity sent from this country. Russian activity in foreign markets, it is true, has recently been temporarily checked by the unsettled condition of the industry at home. But, as soon as it regains the ground lost during the uprisings of 1905, the campaign for world markets is sure to be pushed more vigorously than ever. A large measure of success has crowned the Russian efforts in European and Asiatic markets in the past; to what extent they will drive out the American products in the near future is an absorbing question at the present time for the operators in this country. Whatever the outcome it will be a battle of giant interests for an enormous prize.

Russia, however, did not long remain the Standard's only rival. When the Burmese industry began to grow, the Standard feared the same fate for its Indian trade that it had met previously in Russia. Already foreign oil had to pay a duty which might at any time be raised to a prohibitive scale. The Indian markets were altogether too valuable to be lost, for the local industry could then supply only a small part of the enormous demand. There was, however, no way of telling how

much it might grow, so the Standard sought to get a hold on the Burmese supply by buying leases. But unexpected governmental opposition prevented the Standard from getting any sort of interest at all in the local industry. At the same time, a powerful British company was granted a practical monopoly of the field, thus adding a third

Arecibo, Porto Rico. Burros loaded with case oil for the interior.

highly favored rival for the Indian markets, where Russia was already making serious inroads on American profits.

Galicia and Roumania became competitors to a small degree in the markets of Europe nearest to these fields. Japan for a time threatened to repeat the history of the Burmese field, leading to the unprofitable venture in the International Oil Company, purchased by the Standard to operate fields

which never materialized. The Dutch Indies are the latest and one of the most dangerous rivals to appear. Through their location so near the important Chinese markets, they have very rapidly secured a stronghold on the trade of that country. This Dutch industry is all the more to be feared because the quality of the oil is but little, if any, inferior to the best grades of American manufacture, and consequently it is able to compete on an absolutely equal footing.

It must not be supposed, however, that the appearance of strong competitors in the world's markets has resulted in a curtailment of American exports. Quite on the contrary, they have increased steadily since the very first, most rapidly, of course, during the early years, but none the less surely all the time that this struggle has been going on. Beginning in 1861, the total had risen to over 2,500,000 barrels in 1870; to five times that quantity in 1880; doubled again by 1900; and now equal to some 30,000,000 barrels annually, worth upward of $85,000,000. Such an increase, in the face of steadily growing supplies from other districts, has been made possible by the enormously greater demand in all parts of the world and the untiring efforts of the Standard Oil interests. Strong competition has merely changed the direction and character of American trade.

Kerosene, the greatest article of trade from among the petroleum products is really an American specialty, both by virtue of practice and quali-

ties of crude oil. America, therefore, has had the advantage coming from a superior grade of manufactured product, though this advantage has been lessened recently by technical advances in other countries. American lubricating oils surpass all

Case oil by caravan, Arabia.

that the rest of the world can offer, and in actual value per gallon they stand second to none of the other products. The paraffin oils of this country are without a peer elsewhere, thus making the wax a decidedly valuable article of trade, while naphthas are secured in larger amounts from American crude than from any other yet known. Where dis-

criminative duties place restrictions on trade in refined products, as in France, Spain, and Mexico, the simple practice of shipping crude oil has saved the day for American oil. Added to these natural advantages, the unfailing insistence on the part of the Standard officials for reliable oils of high quality has been well known abroad and has been an ever constant help in keeping valuable markets.

It is impossible more than to hint at the obstacles which the Standard has encountered in its trade round the world: the long struggles to open new markets; in educating half civilized natives to the advantages of artificial light; the time and money spent in experiments; and the slow, often discouragingly slow, successes. Everywhere the Standard has fought its fight on the ground, carrying the struggle straight into the contested territory, usually with a local company under its own domination. Such companies as the Anglo-American Oil Company, in England; the American Petroleum Company, in Holland; the Societate Romana Americana, in Roumania, are found in almost every country where the Standard does a large business. Like their fellows in the United States, they are manufacturing or selling companies, for the Standard abroad has even more rigidly adhered to its policy of not engaging in actual production.

This world-inclusive organization has been one of the main reasons for Standard successes, in just the same way as the union of interests in this country brought it immense power to fight compe-

tition. None of the foreign oil regions possessed this great advantage of a centralized industry. Several Russian operators were strong individually but their strength in outside competition would have been increased tenfold had they worked as a unit instead of separately. At the present time, however, this process of concentration and economy of large operation is going on everywhere at a rate which promises trouble ahead for the Standard. In every oil-producing country the example of the Standard is being copied studiously, profiting from its successes, avoiding its mistakes. The Standard long ago acquired a high degree of efficiency and has labored untiringly to strengthen and perfect its position. Through this efficiency its early victories came so much the easier. Now, however, its rivals are acquiring the same perfection of system and organization, the same concentration of capital, and often, in addition, they have secured the active support instead of the opposition of their governments.

In the East there is the British Company holding a monopoly of the Burmese fields. A powerful combination of the Shell Transport and Trading Company, with the Royal Dutch Company and the Rothschilds' interests, has been completed to control not only the industry of the Dutch Indies but also the distribution of Russian products in the Orient. A single company patterned after the Standard, with almost unlimited backing, now controls about ninety per cent. of the Galician in-

dustry. Legal steps have been taken to oust the Standard company from Roumania, one of the few localities where it has acquired foreign holdings,

Into the Sahara desert with American kerosene.

while a rival organization is ready to assume the control. Baku, at last, also has its scattered interests united by a powerful syndicate of German capitalists. The British interests, forming an important second group by themselves, have been en-

listed with the German concern, to work toward a common end. This means still greater rivalry on the part of Russian oil especially in the markets of Western Europe.

A new era is unquestionably dawning upon the oil business. Every advantage, improvement, or economy that skill and capital can secure will be had by these rival, foreign oil "trusts." Their efforts to perfect methods of refining, handling, and marketing, and to extend the sale of their products will be no less vigorous than have been those of the Standard. A mighty struggle is inevitable. The struggle in the past has been one of unequal forces, the Standard like a perfectly trained army arrayed against disorganized stragglers. In the future it will be a struggle of well-matched forces, each with modern equipment, each with enormous resources behind it. The Standard has the confidence born of many victories; it is well prepared to meet worthy foes. What the outcome will be, no one can foretell. Should the Standard suffer defeat, the blow to operators in this country would emphasize, as nothing else could, the far-reaching importance of the present foreign trade in petroleum products even to the smallest of American producers. Yet from the standpoint of maintaining our supplies for future generations, nothing could be more desirable than to have all the foreign markets won away from this country.

CHAPTER XIII

THE OIL FIELDS OF TO-MORROW

It has recently become a national habit to question the future of important natural resources. The probable duration of the forests, of the coal supply, of iron ore and the like have been the subject of much speculation. For some unaccountable reason, however, the future of petroleum has been ignored, as though it matters little one way or another. Yet, with all truthfulness, petroleum can be said to stand second to no other mineral product. The continuation of the supply of petroleum is fully as important as the continuation of the coal supply. The loss of a good, cheap means of securing artificial light would set the world back a hundred years. Millions on millions of people, whether they know it or not, are vitally concerned in the question of the oil fields of to-morrow. The actual comfort and happiness of these millions hinges on the answer to the question, "How long will the supply last? Is it inexhaustible or is the end not far distant?"

Fifty years ago the annual output of petroleum for the entire world was certainly much less than

1,000,000 barrels. Twenty-five years ago it was not far from 30,000,000 barrels. Ten years ago it was approximately 125,000,000 barrels; in 1907 it was over 260,000,000 barrels and as yet shows no signs of having reached its limit. Petroleum products have been put to such a variety of uses that there is apparently no limit to possible consumption. With the greatly increased use for fuel, the continued success of the gasoline engine, the greater and greater extension of the sale of kerosene to the rural population of the world, to say nothing of the steadily growing favor of other products, all sure to be as marked in the future as in the past, there is little reason to look for any great change in the rate of consumption; certainly no decrease is likely.

A continuation of the past rate of increase during the next fifty years would mean a petroleum industry as much greater than the present, as the enormous operations of to-day are greater than those of Kier's time. If the world output should continue to double each decade in the future, as it has in the past, fifty years hence would see the annual production approaching 10,000,000,000 barrels, or more than four times the entire yield from the United States in the half century since the industry began. It would require nearly 200,000 wells, each giving 100 barrels a day for every day in the year, or an average daily production some twenty-five times greater than that of the wells in this country at the present time. No imagination

can picture the apparatus and organization which would be required to produce and handle such an incredible quantity of oil.

There are few reasons, however, for believing that such an enormous growth of production in the future can be possible. The origin of petroleum and the nature of its occurrence, the character of the industry, the whole history of the oil regions and of individual wells, all point clearly to one inevitable conclusion. This conclusion, in brief, is that the supply of petroleum is strictly limited; that once this supply is gone, no more is to be had, and that the time is not far distant when the limit of maximum production will have been reached.

Many people still believe that the process by which petroleum is formed is a continuous one, or, in other words, that the underground reservoir is constantly being replenished as oil is withdrawn from the well. According to this idea, exhaustion of the supply is a thing of the dim and hazy future. The accepted theory of origin and the known conditions of occurrence, however, very thoroughly shatter this notion. Petroleum is admittedly the product of decomposing organic matter imprisoned in the strata at the time of their formation. It follows inevitably, therefore, that the amount of petroleum which can be formed is absolutely limited by the quantity of fossil remains to undergo decomposition. Hence, when the process of decomposition is once completed, it is through for all

time as far as that particular stratum of rock is concerned.

The strata which are oil bearing have existed in their present condition for untold thousands, probably millions, of years. Hence the process of decomposition must have been completed ages ago, or, if not yet completed, it must be so infinitely slow that the quantity accumulated in a thousand, or ten thousand, years would be entirely insignificant. Whichever way the question is considered, indisputable evidence leads to the one conclusion that the entire supply procurable is now already stored underground waiting for the drill.

This does not mean at all that man can win from nature her whole bountiful supply of the precious liquid. It means merely that certain great accumulations have been gathered under favorable conditions, and these man may have. Other far greater quantities exist in the rocks of the earth, but in such a way as to be entirely inaccessible and unavailable through any method now known.

A single formation, to take a specific example, underlies many hundred square miles of the district south of Lake Erie. The formation is estimated conservatively to be 500 feet thick, and to have a very uniform content of petroleum amounting to about a tenth of one per cent. of its bulk. This quantity is, of course, far below the limit of possible productivity—Baku sands frequently containing as high as twenty per cent. of their bulk—but, small as it is, it means an actual quantity of

2,500,000 barrels of petroleum for every square mile covered by the formation. To duplicate the entire production of the United States up to the present time would require the whole petroleum content from only 720 square miles of that one rock layer. Yet, disseminated as it is throughout the rock, it is entirely unavailable. It is disseminated not because it is of more recent formation than the available supplies, but because the conditions underground have not favored its concentration in a rich pool. Its actual age, in fact, is very much greater than that of some of the most productive supplies now developed. There is, therefore, no cause to suppose that old pools may be replenished, or new pools be forming, from such sources. Every evidence says plainly: Here is so much oil accumulated by chance; take it as fast as you wish, but remember that when it is gone the reservoir can never be refilled.

The history of whole districts and of individual wells tells the same story. The life of pools and wells, of course, varies greatly in different cases. Thus, the Pithole district lasted only a few years and then failed entirely, while the Franklin area near by is still producing high-grade oil after forty years of activity. One well may fail after a few months or a year; others have been known to yield continuously for a quarter of a century. With very few exceptions, however, the original production of a well is greater than at any subsequent time in its life, and the downward career begins

almost from the very moment oil is struck. It may take years for the end to come, but its coming is as sure as the light of day.

The average duration of profitable production from a well is about five years, though a multitude of circumstances cause wide variations from the average. The important point, however, is that profitable production does cease sooner or later, and that as the older wells give out, new wells must be drilled to keep up the supply. This alternative, in turn, ceases to be effective, and the whole region gradually falls into decay. Every locality must eventually reach the limit beyond which the production begins to decline. Such has been the case in all the older pools; such must be the case with every pool discovered until the end of time.

The Texas field affords the most startling confirmation of these facts. Spindle Top began in 1901 with a giant gusher and a burst of glory unrivaled in this country before that date. Wells starting out with 75,000 to 100,000 barrels a day were encountered and gave the pool a production of over 34,000,000 barrels in the first four years of its life. But in 1905 the daily production had fallen to 4,000 barrels a day. All the Texas pools have had the same meteoric career, and, unless new ones are discovered soon, that state will cease to be an important factor in the industry. Even the highly productive Baku district bears in effect the same sort of testimony. Over two hundred wells were opened there in

1888; less than two-score of them were producing at all fifteen years later. Out of 400 completed in 1900, more than a fourth had failed inside of three years—wells which may have taken several years for completion and cost as high as $20,000 each when done. The very life of the petroleum industry depends on unceasing activity in drilling. As far as production is concerned, it is an industry here to-day and gone to-morrow.

The great Appalachian district, so long the leader in this country, is now rapidly approaching its end, and its demise may presage the actual decline of the whole American industry. In 1891 Pennsylvania reached the height of its long career with a yield of over 33,000,000 barrels, but since then the downward course has been steady. To-day the entire Appalachian field from New York to Tennessee yields less than two thirds of that amount. Other fields in this country are going the same way. Ohio, which reached almost 24,000,000 barrels in 1896, had fallen to hardly more than 12,000,000 in 1907. Texas dropped with unparalleled rapidity from 28,000,000 to less than half that quantity in two years. They tell the story of oil with absolute truth. In each of these older fields thousands of new wells have been drilled annually during the whole progress of the decline, hundreds of thousands of wells in all, without sufficing to maintain the former supply. Every year has seen an increasing percentage of "dry" holes, until now many districts are so far

depleted that one out of every three wells sunk fails to yield oil.

This decline in the Appalachian field has come just when the demand for the highest grade oils is greater than ever, and growing annually. The rapidly increasing use of gasoline and the other lighter products of distillation cannot well be met from the supplies of heavy asphalt oils from the Gulf and the California fields. Already many wells reported as productive have really reached a condition where the production, amounting perhaps to less than a barrel a day, can be done at a profit only through the strictest economy or because the oil is of a special quality. Unless some new supplies of high-grade oil are discovered soon, the price of the lighter refined oils must advance, and the heavy drain on the Appalachian region will result in speedy exhaustion.

The ultimate fate of every petroleum-producing region is plainly written in the character of the deposit. Every well, every locality, shows essentially identical stages of development. The well begins as a gusher, perhaps, gradually ceases to flow, has a pump installed, and finally ceases to yield at all, as salt water appears in the pipe. Every step is steadily downward. The locality begins with a boom, yielding enormous quantities for a time, settles down to steady production; then wells begin to fail, others can be operated profitably only by adopting the most economical methods of pumping, perhaps a hundred or more in

one multiple system; new wells fail to find oil; and the end is close at hand.

Many wells in the Appalachian region at the present time can be operated profitably only because a local supply of natural gas permits the use of the cheapest kind of power in the form of gas engines; in whole sections, the industry is kept alive solely by this means. The failure of the gas supply would mean not only the immediate abandonment of thousands of wells now yielding a few gallons a day but also a greatly increased cost of securing the oil from other wells. Fields less abundantly supplied with stores of natural gas, as appears to be the case in many of the newer localities, must inevitably reach the limit of profitable operation more quickly. As it is with individual wells and separate localities, so it must be sooner or later with whole countries.

The important point in the future of petroleum, therefore, is easily foreseen. As long as new localities can be discovered and developed rapidly enough to counterbalance the decline of old fields, the industry will continue to flourish. It is not impossible that even some of the older localities may witness a revival of operations as the future brings improved and cheaper methods of deep drilling. In certain parts of the Appalachian district, for example, strata known to be oil bearing elsewhere can be reached only with wells 6,000 feet deep, and such deep drilling has not yet been undertaken. If valuable accumulations of petro-

leum do lie thus deeply buried, important developments from that source may come long after the upper strata have been completely exhausted. This possibility, however, is comparatively remote, partly because the existence of deposits at such great depths is still purely hypothetieal, and partly because the cost of produetion from very deep wells would be greatly increased over the present figures.

The principal hope for the future rests on the results obtained in the plaees where surface indications of petroleum are known to exist. The character and extent of these deposits ean be revealed only through future attempts at commereial development, but there are many reasons justifying the belief that deposits, as rieh as any now worked, are still untouched. The future will eertainly see profitable oil industries earried on in many regions where a beginning is yet to be made, perhaps in localities so far not even associated with the name of petroleum. These unproved deposits, if they fulfill all expectations, will at first mueh more than counteract the decline in older fields. Thus, the prospeets of an increased world's produetion, for a time at least, are exeeedingly good.

Russia undoubtedly possesses far greater petroleum deposits than any other country, and is apparently destined to lead the world. There is, of course, no telling to what extent the industry may develop in the Dutch East Indies or in some of the little known portions of the different eonti-

nents, but, in the light of present knowledge, Russia stands unrivalled. Enormous tracts of oil-bearing territory are known to exist in the vast area of the Russian Empire, in fields which the government will not yet open to exploitation. The Baku oil field apparently extends beneath the Caspian Sea because the eastern shore, opposite Baku, is marked by the rich deposits of the trans-Caspian provinces. The opening of the trans-Caspian Railway stimulated exploration of the resources of the district traversed, and all the signs indicate valuable fields of petroleum nearly parallel to the railroad. No developments of any importance have been undertaken here, however, partly because of its isolation from markets, but mainly because the government fears that overproduction would injure the whole industry, and consequently refuses to allow exploitation. The government has not forgotten the enormous waste during the early days of some of the Baku pools, when millions of barrels of oil were burned merely to be rid of it.

Petroleum deposits are known to exist over a great extent of territory in eastern Siberia, where development must wait for transportation facilities to carry machinery, supplies, and shipments of oil. The existence of large quantities of petroleum has been proved in the northern part of the island of Saghalien, now held by Russia. Test wells there are said to have given promise of fully equaling some of the greatest of the Baku spout-

ers. Though no extensive development has yet been undertaken, this Saghalien field is admirably situated to dominate much of the Oriental trade. These untouched Russian deposits stand as vast reserve stores for future use, when the enormous resources of the Caspian shore shall have been exhausted, or are no longer adequate to meet the increased demands. It is not at all unlikely that these localities in far-off trans-Caspia and Siberia will eventually become the mainstay of the world's petroleum industry.

Other Asiatic deposits are also known in addition to those in Russian territory and those already worked in India, Burma, and Japan. Explorations in the desert, on the frontier between Persia and Turkey in Asia, have revealed the existence of valuable petroleum fields, and already a large English company has secured a sixty-year concession to carry on their exploitation. This same oil territory, moreover, apparently extends to the northwest across the border into Turkey, for fields of large extent have been discovered in the district near Bagdad. A concession for working these deposits has been secured by the company constructing the Bagdad railroad. Not enough development has yet been done to indicate the value of these deposits, but, even if they do not prove to be as rich as their neighbors at Baku, they will be of inestimable value in that country, now so destitute of satisfactory fuel. Any surplus above home consumption will find profitable markets

close at hand, for the great population of India probably must always look to the outside world to secure much of its supply.

The work of development has already been begun in Beluchistan, the Punjab, and Assam, the last-named place said to have promise of a very good future. The Philippines, Formosa, and New Zealand show unmistakable surface signs of petroleum deposits, though all developments so far undertaken have been failures. Lack of capital, however, has had much to do with this poor success. Whatever other oil-bearing localities may be found in the vast stretches of Asiatic territory, there is little doubt that the whole world might now easily draw its entire supply from the rich fields already known to exist there. It seems inevitable that all the great markets of the Orient must before long be lost to the western world through the development of Asiatic resources.

The United States has no such reserve supplies of petroleum as are found in the territory of its rival—Russia. Some of the less accessible districts of the West, however, hold out good prospects, especially in the case of the various fields in Wyoming. The limit of production in the great Kansas field is probably not yet reached. Alaska appears to contain several oil-bearing districts which may become second Klondikes. New developments may come at any time in Texas or in some of the little-known deposits of Montana and New Mexico. Unless the unexpected happens, however, it is more

than likely that this country has already risen nearly to the height of its career. A continuation of the recent decline in Texas and the constantly heavier drains on the older fields, hastening an already rapidly approaching end, will mean the necessity of new developments far beyond anything in sight now, to carry the production for any length of time much above its present high level.

Various other countries of the American continents are likely to appear in the list of important oil fields of the future. What is regarded as perhaps one of the greatest fields in the world lies in the west and northwest of Canada. Twenty years ago a royal commission recommended setting aside as a great petroleum reserve some 40,000 square miles in the vicinity about the Athabasca River and in the present province of Alberta. Recent settlement in this region has been accompanied by successful oil operations, the excessive freight rates from the Eastern markets having created highly favorable conditions for undertaking ventures of a very modest nature. Improved transportation facilities will make these deposits an important factor in the future industry, if the present investigation in the interests of the British navy gives encouraging results.

Mexico was long regarded as a country devoid of extensive petroleum deposits; in fact, large cash inducements were offered by the government to anyone who would discover an important field. Recently, however, the country has sprung into

prominence through the greatest and most spectacular oil fire ever known, burning for two months, with successive explosions, converting the well into a veritable volcano, and flames reported to be shooting more than a thousand feet into the air. Defying all efforts to check its fury, it is estimated that not less than 5,000,000 barrels of oil were burned in the first six weeks of its strange career. Such a quantity easily rivals the production of the greatest wells of the Caucasus. It must be regarded as indicating the presence of very rich deposits in the Tampico district where the well was located. Numerous other Mexican localities have given satisfactory results in recent test wells, but none of them have approached this prodigious outpouring in the burning well of San Geronimo.

Nearly all the important South American countries contain known petroleum-bearing areas, though Peru alone can boast at present an actual industry of any prominence. Brazil, Argentine, Chile, Bolivia, Colombia, and Venezuela, all furnish surface indications of extensive desposits, but, with few exceptions, systematic development is yet to begin. What such operations might yield is purely a matter of conjecture. Companies have already been formed in Chile and the Argentine to carry on operations, and it is not unlikely that their ventures, if successful, will lead to an important petroleum industry in South America. The lack of capital appears to be the principal obstacle to overcome.

Africa is entirely too little known to allow any satisfactory estimation of its petroleum possibilities. Deposits are, however, already being developed in Algeria and Egypt, where bright prospects are said to exist. South Africa, too, has lately been added to the list, most pronounced indications of petroleum having been found in the Walkerstroom district. An abundant local supply of good fuel oil would be of incalculable assistance in the industrial development of this region.

Nature's vast and mysterious underground storehouse doubtless contains many other accumulations of petroleum which are now unknown—perhaps never will be known; accumulations which may be much greater than any so far tapped by man. Any one of a hundred known indications may lead the way to another Baku, for there is no logical reason why other equally productive areas should not exist. But, without unknown localities to be discovered in the future, without productive localities of the Baku type, there are apparently enough proven fields in existence to insure the world's supply of petroleum for some time to come. When these fields have repeated the history of Pennsylvania or Ohio, the end of the industry will be at hand. Everything, of course, depends on the rate at which consumption increases during the next fifty years, and the results obtained by future systematic developments in the fields scattered all over the different continents. Should every new field prove to be a second Spindle Top,

enormous overproduction would be quickly followed by practical exhaustion. A comparatively few developments like the great Baku or even the Appalachian field, on the contrary, will suffice to keep the industry going for many generations. Where the world would look for light, if the supply should fail, cannot be answered easily.

The forests can be saved or restored by human efforts. Water power is supplementing or replacing power from burning coal to an increasing extent every year. Even iron is so universal in nature that new metallurgical processes would make available unlimited quantities from minerals now regarded as worthless. Not so with petroleum. Human efforts can never replace the exhausted stores, neither is there any practical way of supplementing its use by other substances, or of increasing the available supply. Petroleum is doomed to disappear. Almost as soon as a new field is opened the search for its successor must begin. The supplies of to-morrow cannot be furnished from the fields of to-day. Not the present generation nor the one next to come is likely to see the supply fail, but both are sure to see changes such as the industry has never shown before. With a continuation of the present conditions no power on earth can avert the speedy exhaustion of the fields in this country. Standard Oil will be a thing of the past, and America will have to seek her oil in the countries where she long held undisputed sway in the oil trade, and where

she has given so largely of her own abundant supplies.

The oil fields of to-morrow lie in the remote parts of the earth, where man has not yet penetrated in great numbers. They lie in the desolate wastes of Russian Turkestan and Siberia, in the unclaimed empire beyond the Rocky Mountains and in the Canadian Northwest, in the vast plains of our sister continent to the south, and in the heart of Africa. The enormous industry of to-day is but a little child beside the giant which must develop these fields of to-morrow, and spread their products to every fireside in the civilized world. Man must have light and the ends of the earth must yield up their whole store of hidden treasures to supply him.

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THE END